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HYDRAULIC COMPRESSED AIR IN CONNECTICUT.

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[*Read September 15, 1904.*]

The use of compressed air for the development and transmission of power is very old. On the walls of a tomb in Egypt, there is a representation of two men standing on leather bags of air, alternately pressing them down with their feet, to produce a blast for a furnace. The ancients used compressed air in blow guns, in forming jets for fountains, in blasts for forges, and for other purposes. Papin used compressed air for forwarding packages, in tubes, two hundred years ago in France. It has long been used in diving-bells and in tunneling. Brunel used it in tunneling under the Thames in 1825. In 1849 compression was proposed to be performed in stages, with inter-coolers between each stage, to get 750 pounds pressure for locomotives.

The first successful use of compressed air for the transmission of power, as now known and used, was at the Mt. Cenis tunnel in 1861, where air was compressed to five atmospheres by two methods, one being by pumps or rams in which water was the piston, but though the air came in contact with the water, it was only slightly cooled, at the surface of the water and around the walls of the cylinders.

About 1870, at Vienna, and later in Paris, a system was installed for working and regulating a great number of clocks by the use of compressed air from a central station. This soon developed into an extremely important system of power transmission. Paris

now has great compressor plants supplying 25 000 horse-power, and more than 50 miles of distribution pipes, supplying air at 75 pounds pressure to thousands of customers, who use it for every purpose, from cooling beer or dusting furniture, to running electric light dynamos. A little stove, with a common kerosene lamp, is used to heat the air before use in the small motors. The motors in use range in size from one tenth of a horse-power to 150 horse-power, most of them being less than one horse-power. They are started or stopped by simply opening or closing a valve.

The cooling of the air while it is being compressed, and reheating it for use in engines, are matters of great importance. If the air is cooled as it is being compressed, the volume will be much smaller, under a given pressure, than the same amount of air would occupy if allowed to retain the heat caused by compression. Then again, if the compressed air is heated just as it enters the engine, the volume will be much increased, while the same pressure is maintained. The economy in using coal for developing power in this way is so great that four or five times as much power can be secured from a pound of coal, through reheating the air, as can be secured through making steam. The reason for this is chiefly that a great portion of the heat of the coal is absorbed, and becomes latent and ineffective, in turning water from the fluid to the gaseous form in making steam power, and no such loss occurs in expanding the air and so increasing *its* power. It is feasible to increase the power of an air engine fifty per cent., by such reheating of the air.

The method of compressing air by entraining it in water, and causing it to pass down in the water to a great depth, so that it is subjected to a great weight of this incompressible fluid, is an ideal one. In this way the air is compressed isothermally, the heat of compression being absorbed steadily by the surrounding water, and the air is, therefore, delivered to the pipe line as cool as the water through which it has passed. The compressed air is also drier, or will be when used in the motor, than the atmospheric air from which it was withdrawn. This comes from the fact that the surrounding water absorbs the moisture precipitated from the air as its capacity to hold water is diminished under compression. A dry, cool air is thus secured for the dis-

tribution system, comparatively free from the danger of freezing on its way to the motor, or on its expansion in or from the motor. Where there is no moisture to freeze, there is no freezing.

I have been asked to describe to you, briefly, some of the features of a recent installation of a plant for the hydraulic compression of air, to be transmitted a few miles for use in the development of power. This plant is on the Quinebaug River, just above its junction with the Shetucket River in Connecticut, and alongside the track of the Norwich & Worcester Railroad, near the point where the track passes through a tunnel; which fact has given the name of the tunnel privilege to the falls which have been utilized by the establishment of this plant. At this point the river passes through a narrow, rocky gorge, and to utilize the full fall available, the surface of the water above the dam must be brought within a few feet of the level of the track. This condition made necessary the adoption of devices for limiting the height to which flood water would rise over the proposed dam, so as not to overflow the railroad track. For this purpose the length of overflow on the dam was increased, so far as practicable, by laying the plan of the dam somewhat in the form of the letter Z, thus about doubling the length of the overflow of the dam, and of course, correspondingly decreasing the thickness of the sheet of freshet water passing over it. Another device consisted in the establishment of automatic flashboards, so designed that with the water at the normal stage of the river, the flashboards would retain their position and hold the water to the full allowable height, but upon the increase in the discharge of the river, and consequent rise of the surface above the level of the flashboards, they would turn to a nearly horizontal position and so open a passage for the water to a level between three and four feet lower than the top of the flashboards when in their normal positions.

In the plan, Fig. 1, the positions of the screen, gates, and compressor tank are to be seen upon the left bank of the river. The shore and the bed of the river at this point are of ledge, but the bed of the stream had been filled in places to a considerable depth by bowlders unattached, though compactly placed, and it was not considered safe to form the dam upon any other material than the solid ledge in place. Laborious and expensive excava-

tion was necessary in some places to uncover the ledge, and at points excavation was made considerably below sea level.

To protect the men from inundation by the water in the river, coffer dams were erected, covering successively different portions of the excavation, and these coffer dams were generally formed of square-edged planks, set vertically and supported by timber cribs.

The dam is formed of what is called Cyclopean concrete, consisting of Portland cement mortar with stone, gravel, and sand

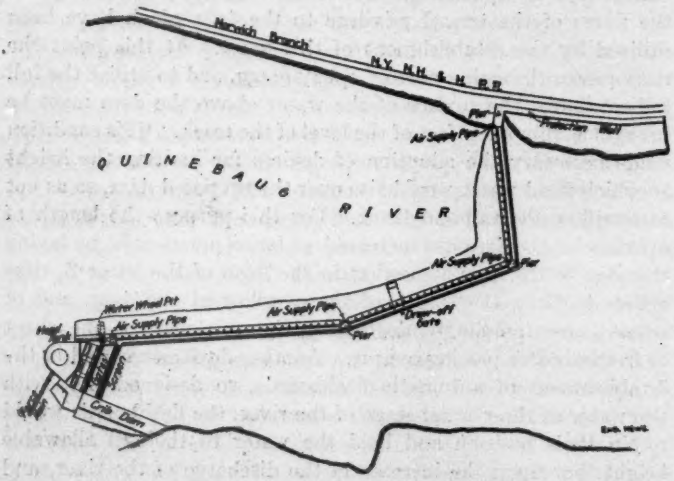


FIG. 1.

of varying sizes up to those as heavy as could be handled by the derrick. These materials were so mixed that no two pieces of large size would touch each other, but every piece was surrounded and encased in materials of less size down to the fine powder of the Portland cement. These materials were so placed as to form a dam of the necessary stability, and the form of section for this purpose, as adopted, is shown in Fig. 2.

The materials, while the cement was setting, were held in position by forms of plank set to enclose the dam and removed when

FIG. 1. SHOWING FORMS AND CHARACTER OF CONCRETE.

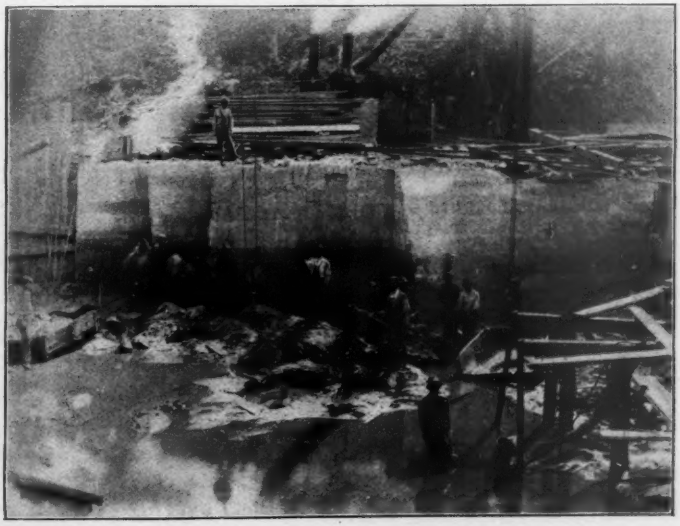


FIG. 2. JUNCTION OF SECTIONS OF THE DAM.

the mortar had set sufficiently for that purpose. The positions of some of these enclosing forms, together with the character of materials used, may be seen in Plate I, Fig. 1.

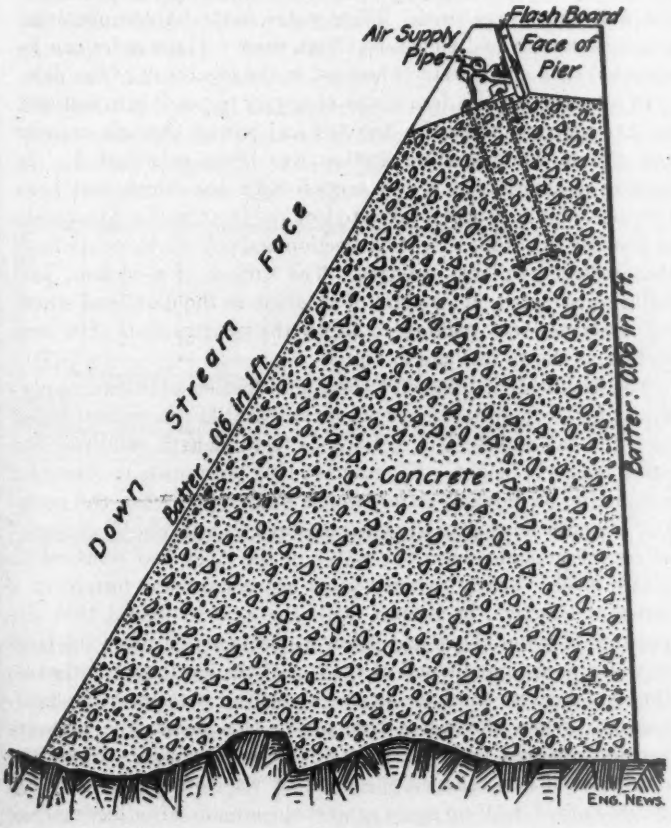


FIG. 2.

When the concrete structure had arrived at a sufficient elevation to form the floor of the inlet to the compressor, the surface was carefully leveled and floated and troweled to the right ele-

vation. This was at the lower end of the dam on the left bank of the river.

It was necessary to control the access of water from the river to the head tank of the compressor, and for this purpose substantial mill gates were used. These gates control three openings, eleven feet wide and eleven feet high each. These gates can be operated by a small water wheel set in the head wall of the dam.

In constructing the dam it was necessary to put it in in sections, so that the river might be diverted and passed through or over one section while another section was being constructed. In making a junction of a new section with one which had been previously built, care was taken to lock the two together as securely as possible to obtain a tight connection and one which would have the greatest available strength. The surface of a section, partially constructed, at one end of an angle in the dam, and where preparations were making to begin the construction of a new section, is shown in Plate I, Fig. 2.

The flashboards, designed to open and furnish additional opportunity for storm water to escape, are substantial structures, formed of white oak and steel, in sections six feet in length and three feet seven inches in height. Efforts have long been made to construct automatic, or movable dams, which would open when the quantity of water flowing in the river required it, and would, of themselves, close again when the water in the river had returned to a safe level. Nearly seventy years ago a dam was formed of a series of shutters, in France, with the axis so placed that the pressure of water above and below would be equal when the level of water in the pond stood at the top of the flashboards; that is, the axis was one third the height above the bottom of the flashboards. When the water rose above this point, the pressure became unequal and was greatest above the axis. When the dam opened and relieved the pond, it was found that the dam would not set itself up again against the stream, after having once opened, and therefore the automatic action sought for had not been accomplished. In the present instance the flashboards are so hung that they do automatically, and gradually, open and close as the water rises above the crest or falls to a level with it. Some details of these flashboards are shown in Fig. 3, and a view

of the top of the dam with flashboards wedged in various positions is shown in Plate II, Fig. 1. When the water in the pond is at its normal level, and the flashboards are in their normal positions, the point of bearing on the axis is at one third the height of the flashboards above the bottom, or at the center of the pressure of the water. The lower portion of the flashboard is so weighted that the center of gravity of the moving parts is below the point of bearing, and upstream from the perpendicular line drawn through the point of bearing. The flashboard is hung on a rolling hanger, confined in place, having such a form that as the height of water against the dam increases and tips the flash-

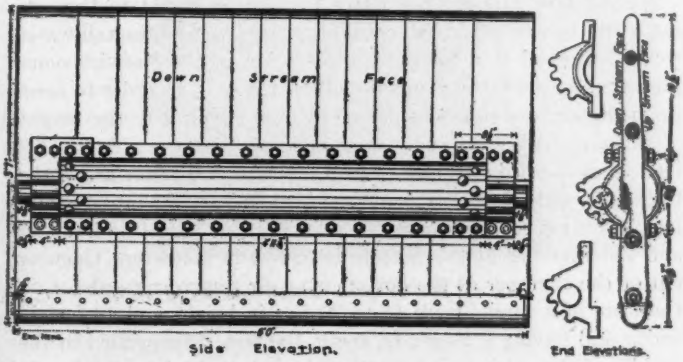


FIG. 3.

board, the resisting point of the flashboard rises to meet the new center of pressure and the resultant forces produced by the moving water. In its new position, the resistance of the flashboard to motion, and the forces tending to move it, are in equilibrium so long as there is no change in the volume of water flowing, but as this volume changes, the flashboard assumes a new position, either wider or less open, as the quantity of water continues to increase or decrease. This result arises from a combination of overbalancing weight, in the lower part of the flashboard, aided by an equalization of the areas above and below the point of bearing, on which the forces, caused by the moving water, act when the dam is open. The device is simple and massive. The

frames on which the hangers roll and to which they are confined are well anchored to the masonry and are so constructed as to furnish a stop to the flashboard when it is fully open, to prevent the possibility of its passing beyond a point where it could be favorably acted upon, as the level of the water in the river retreats to its normal height. These flashboards have now gone through several winters, with their freshets, accompanied by ice, logs or uprooted trees or other floating matter and have withstood all this without resulting injury, and they have worked satisfactorily in allowing increased opportunity for the escape of freshet water and in withholding the pond level to its normal height.

Having now brought the water to such an elevation that we can avail of a sufficient fall between its surface and the tail water we will proceed to a further consideration of the Norwich compressor plant with the available fall of 22 feet. In order to compress the air to a sufficient degree by submitting it to the weight of a head of water, a shaft was sunk vertically to a depth 208 feet below the bed of the river or 215 feet below the surface of the tail water, and at the bottom this shaft was enlarged into a chamber to contain the air separator. The shaft is 24 feet in diameter and the chamber at the bottom is 52 feet in diameter. Opening out of the chamber at the bottom is an air reservoir regulator, in the form of a tunnel from 15 to 20 feet in height and 18 feet in width and having a length of about 100 feet. Suspended in the middle of the shaft is a downflow pipe of steel, about 14 feet in diameter, connected at the top with the head tank, through which water is received from above the dam, and at the bottom with a separator chamber. This chamber is surmounted by an air reservoir, to contain the compressed air when separated from the water in which it had been entrained, and with which it had been carried to the bottom of the shaft. From the air reservoir over the separator, a 16-inch leading main rises to the surface, and is laid toward Norwich, conveying air under about 90 pounds pressure for the use of the engines at the several establishments employing it for power. A general idea of the shaft, down-flow pipe, separator, leading main, etc., can be obtained from Fig. 4.

In sinking this shaft through the ledge, below the bed of the

FIG. 1. VIEW OF CREST OF DAM, SHOWING AUTOMATIC FLUSHBOARDS.

FIG. 2. VISIBLE PORTION OF COMPRESSOR IN ACTION.

river, it was found that the upper portion was not sufficiently strong to serve for the permanent walls of the shaft, and for a

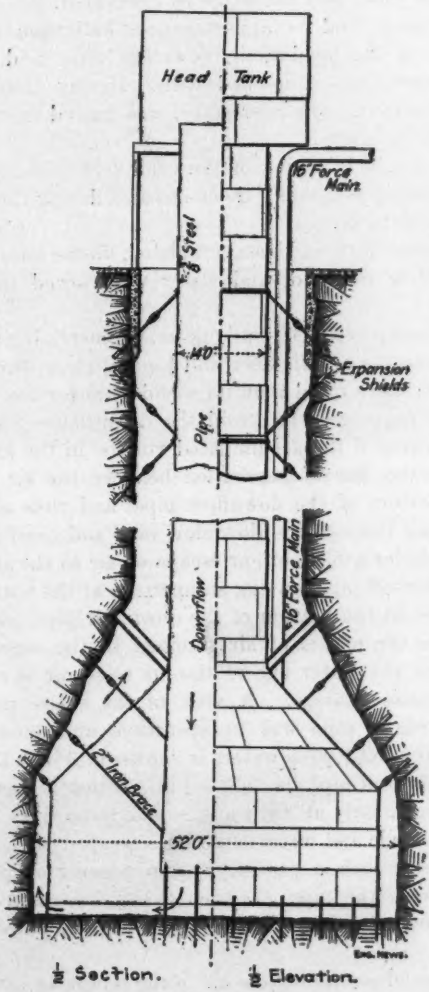


FIG. 4.

considerable distance the excavation was lined with concrete, formed by filling a space between curbing, inserted for the purpose, and the surface of the ledge as excavated.

After the shaft and its appurtenances had been completed, the erection of the head tank, downflow pipe, and separator, formed of steel, was proceeded with. During this time, the flow of the river, at whatever stage, was passed over the dam, or through a sluiceway.

Plate III, Fig. 1, is a view of the head wall, with a portion of the dam, looking diagonally down-stream, during the construction of the separator.

After the steel work had been completed, all the false works and accessories were removed, and water was turned through the apparatus.

When the compressor is in full operation, entraining the air and supplying it to the air chamber and leading main, the collection of air may be more rapid than its withdrawal for use in engines, or for other purposes. To avoid the disturbance which would be likely to occur if the accumulated volume in the air chamber should force the line of separation between the air and water below the bottom of the downflow pipe, and thus allow of an eruption of air through the downflow pipe and head piece, provision is made for a blow-off, or escape of air to the atmosphere, through a blow-off pipe, having an aperture at the bottom higher than the level of the bottom of the downflow pipe, and through this aperture the excess of air supplied to the separator may escape, before the water line in the air reservoir is carried low enough to cause damage. A view of the entire plant, taken while this escape pipe was in operation and blowing off a surplus of air mixed with water, is shown in Plate III, Fig. 2. When this blow-off pipe was first set in position it was turned so as to discharge nearly at right angles across the river, and it was found that the air and water sometimes escaped with such force that it would drench a passenger train passing over the track. The direction of the pipe was then changed so as to discharge diagonally down the river, as now represented, and where it could do no harm.

The process of entraining the air to the separator before its pas-

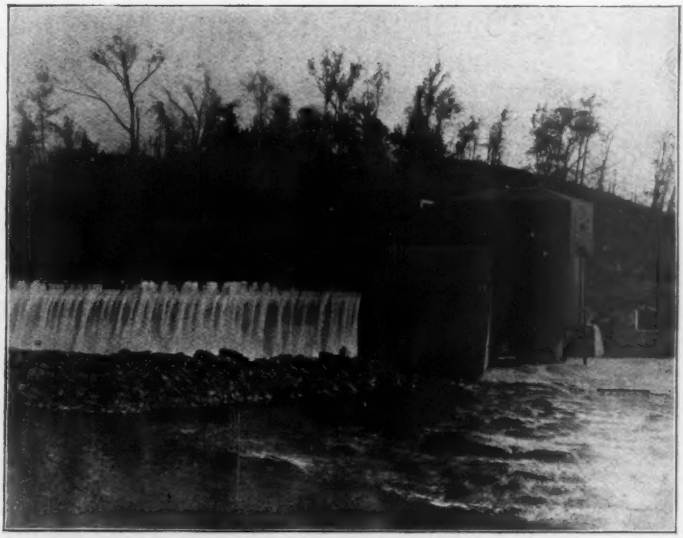


FIG. 1. VIEW OF PORTION OF DAM-COMPRESSOR UNDER CONSTRUCTION.

FIG. 2. BLOW-OFF IN OPERATION.

sage with water through the compressor is accomplished by submerging orifices, or air pipes, below or in contact with the surface of the flowing water; such apertures or pipes having proper channels for a free communication with the outer air. The air being in contact with the flowing water is entrained by it, and a partial vacuum being caused thereby, a sufficient pressure is induced to cause a free flow of the outer air through its proper channels to the water. Having been entrained there, at the ordinary atmospheric pressure, the air is carried down in bubbles with the water, and is steadily compressed as the depth of the water increases until, as in this case, it reaches a pressure of about seven atmospheres. Having escaped from the water by floating out of it as the water passes slowly through the separator, it retains, in the air chamber, the pressure due to the weight of the column of water having the height equal to the difference in level between the tail water escaping from the apparatus and the line of separation in the air chamber between the accumulated air and the water out of which that air has floated.

The volume of air which can be carried down with water depends somewhat upon the fall, or the difference of level between the pond water and the surface of the tail water. The greater that difference of level, within reasonable limits, the greater the volume of air which can be carried down with water. In this case, apparently the volume of air is about one third that of the volume of water passing through the apparatus. The combined volume, formed of a mixture of air and water, is of course lighter than a column of solid water, and the aërated column cannot be quite so much *longer* than the solid water column as is represented by the amount of the fall, because a certain amount of force, represented by a portion of the fall, is necessary to cause the mixture of air and water to flow through the separator. I know of no experiments bearing directly upon this matter, but it seems probable that a limit of the volume of air which could be entrained and carried down by a surrounding volume of water, would be reached when the aërated column is about fifty feet longer than the solid water column.

There are various means of measuring the amount of air which may be supplied from a given source, the most satisfactory of

which probably is to pass it through an air meter, having the usual recording attachment operated by clockwork. Various observations have been made upon the amount of air which would pass through an orifice, shaped approximately like the contracted vein formed when a fluid passes under pressure through an aperture in a thin plate. The volume, or weight, of air in pounds per second, may be ascertained, with reasonable accuracy, by taking the area of a circular orifice of this form, in square inches, and multiplying that by the *absolute* pressure, in pounds per square inch, entering the orifice, divided by the square root of the *absolute* temperature, in degrees Fahrenheit, and the whole multiplied by a coefficient varying somewhat with the area of the orifice. For an orifice of one inch diameter the coefficient may be taken at .53.

It is of great importance that the pipes leading the compressed air from the source of supply to the point of use shall be tight, and it is much more difficult to secure such tightness with air than it is with water, or even with steam. Cast iron as a material for such pipes has been very successfully used, but if the joints have been formed in one piece with the pipe, they cannot be successfully made tight by calking with lead, in the manner found to be safe in conveying water.

The joint most extensively used in Paris, and found to be satisfactory there, is formed upon cast-iron pipes having a plain spigot at each end; having brought two pieces of pipe together, place over the joint so formed a short sleeve, nearly fitting the pipe, and long enough to fully cover the joint under such variation of position as may arise in practice. Against each end of this sleeve is placed a rubber ring or gasket, and these rubber rings may be pinched against the ends of the sleeve by other properly formed sleeves or hubs, encircling the pipe and having flanges through which bolts may pass, the hubs being drawn toward each other by nuts on the bolts, thus squeezing the rubber ring between the hub, the sleeve, and the pipe. It is necessary to select a kind of rubber well adapted to this service, in order to secure a permanently tight joint, but with materials properly selected and properly applied, the leakage has been found to be so small that it may be neglected in estimating the amount of air which may be delivered from a distribution system.

In cases where it is desired to substitute another form of power in works where steam engines have been used, compressed air has a great advantage over electricity, in the matter of economy. It is not necessary with air, as it is with electricity, to install new motors at the works, but the engines which have been previously used with steam are well adapted for use with compressed air, thus avoiding considerable expense which would be necessary for electric motors.

In Magog, Canada, I inspected the operation of a plant where air had been compressed by water, in a manner similar to that in operation at Norwich, and where a number of engines were running to drive printing presses for printing cloth. I asked the machinist if there was any special trouble in substituting air for steam in an ordinary engine. He took me into the machine shop, where an engine was driving the machines, and operated by steam. A connection had been made to this engine from the air compressor, and two pipes, one leading steam and one leading compressed air to the engine cylinder, lay side by side. The machinist took hold of the steam valve with one hand, and the air valve with the other hand, and gradually closed the steam valve and opened the air valve, until the engine was running entirely with compressed air instead of with steam. After running a few minutes in this way he reversed the process, gradually closing the air valve and opening the steam valve, until the machinery was being again driven entirely by steam power. Both operations were performed without any apparent change in the running of the lathes and planers, or other machinery, and it is probable that no machinist in the shop knew that any change in the power had been made. The only disturbance during the entire operation, that I noticed, was a slight sound of thumping in the engine, when the air was shut off and the steam re-introduced, probably caused by the condensation of a small amount of steam when passing into the cylinder, which had been cooled by the compressed air. Any non-condensing steam engine seems to be well adapted to driving by compressed air, whether used at full stroke or under cut-off, the substitution of air for steam being made without changing the engine.

I have before mentioned that a great economy in the use of

compressed air for power purposes may be secured by reheating the air just as it enters the engine. An economy of from 30 to 40 per cent. is sometimes possible in this way.

Compressed air has a great advantage, when it is desired to use transmitted power intermittently, and with periods of non-use intervening with periods of use. There is no loss in maintaining this power when it is not in use. There is no leakage like the leakage of electricity. There is no reduction of pressure like that caused by the condensation of steam. The whole power is available whether used continuously or at intervals.

Each method of producing or transmitting power, whether by steam, or gas, or oil, or electricity, or compressed air, has advantages of its own under favoring conditions, but the use and value of compressed air seems heretofore to have been but partially known and poorly appreciated. I quote from Richards: "The use of compressed air has been slow of development, and is still backward, but at this writing I am able to enumerate two hundred distinct and established uses of compressed air, and in more than ninety per cent. of those uses electricity is absolutely inapplicable, and in the remainder, which form a field more or less open to other agencies besides either air or electricity, the air generally has the advantage."

In the Norwich plant the production of compressed air is very uniform and the pressure is held steadily at about ninety pounds while the compressor is in operation. A card from the pressure recording gage shows that the pressure for the whole twenty-four hours varies only about two pounds, standing at just ninety pounds nearly all the time. The water, when this card was taken, was turned through the compressor, begininng at a little before five o'clock in the morning, and in about ten minutes the card represented the full amount required to carry the pressure from that existing through the night to the ninety pounds which is the standard pressure. At about fifteen to twenty minutes after five in the morning, the distribution pipes are blown off, to free them from any possible moisture which may have gathered over night, and this operation is shown by the reduction in pressure of about one pound. This pressure is, however, restored in about ten minutes and from that time to midnight the full pressure of ninety pounds

is uniformly maintained. After that time until 4.45 in the morning the pressure shows a gradual reduction of about two pounds, but I am informed that this is not probably the result of leakage, but that small amounts of air are drawn, for various purposes, during that period in the night. Daily cards are taken, the change from one card to another being made at about nine o'clock in the morning.

The air delivered from the Norwich plant is in use in over forty engines, and its employment is a source of great satisfaction to the men who formerly were obliged to reach the works by 4 or 4.30 in the morning, to get up steam and have everything ready to start at 7, and who now have the comfort of waiting until a few minutes before 7. Upon arrival they simply turn a valve and the machinery starts off at full speed.

DISCUSSION.

MR. EDWARD ATKINSON. I should like to ask if this power is sold.

MR. SHEDD. It is sold to various small factories in Norwich and vicinity, which formerly used steam and are now using compressed air in its place. I have nothing to do with the financial part of the business, and I do not know what the prices charged are, but these concerns at least have preferred to use air at the price at which it is sold rather than steam which they had been using.

MR. ATKINSON. It was a question in my mind as to whether at the price at which it is sold it pays the promoters.

MR. SHEDD. That I am unable to say.

MR. T. H. MCKENZIE. Are the pipes laid as water pipes are, below the frost?

MR. SHEDD. No; most of them are about four feet deep, but really there is no occasion to lay them below frost, except that it is desirable to have them so low that they will not be thrown by the frost.

MR. MCKENZIE. Why does the air blow-off blow both water and air?

MR. SHEDD. Because the inlet to the blow-off pipe is just at

the level of the air and water, and as the air begins to pass out it carries water with it, so that water and air are discharged.

A question has been asked me as to how the flashboards have worked in practice. The only trouble they have had from the flashboards has been that when they are open leaves flowing in the stream sometimes catch in the seats and flashboards do not entirely seat themselves afterwards, so that there is a little leakage for a time until the leaves are cleared from under the seat.

MR. FRANK L. FULLER. I should like to ask Mr. Shedd in regard to utilizing the different amount of flow at different seasons of the year. I think all the slides which were put upon the screen showed water running to waste.

MR. SHEDD. Yes; the plant is adapted to 1 500 horse-power, and the stream is usually capable of developing considerably in excess of that amount of power. Water, of course, is running to waste over the dam when there is only 1 500 horse-power or less going through the compressor. When the compressor is taking a less quantity, adjustment is made in the headpiece.

MR. FULLER. I presume it is quite a variable stream.

MR. SHEDD. Yes; but it is pretty well reservoired. As near as I remember, there are forty-three different storage reservoirs on that stream. It rises in Worcester County in Massachusetts, and there are a great many mills on the stream; it has been very well developed for manufacturing purposes.

MR. FULLER. Could not another compressor be used when there was plenty of water?

MR. SHEDD. Yes; there is an opportunity to place another alongside of this one. Everything has been so arranged that no disturbance would occur if another compressor of equal capacity were set alongside of this.

MR. MCKENZIE. Is there any patent on the apparatus for the flashboards?

MR. SHEDD. Yes, there is.

MR. MCKENZIE. Who owns it?

MR. SHEDD. I guess it is pretty nearly free.

MR. MCKENZIE. What do you mean by its being pretty nearly free?

MR. SHEDD. Well, there wouldn't be much objection to anybody using it for these purposes.

MR. ALBERT F. SICKMAN. I would like to inquire if you know what the efficiency of this compressor is?

MR. SHEDD. The efficiency has not been measured at this place particularly, but I took part in several experiments as to the efficiency of the plant of Magog, and that ranged from about sixty-two per cent. to a little over seventy per cent. The highest efficiency we obtained was a little over seventy per cent.

MR. SICKMAN. Under what conditions would that be obtained? When you are using a great quantity or a small quantity?

MR. SHEDD. It is when using the quantity to which the compressor is adapted. I believe the local engineer has said he thought he could obtain somewhere near eighty per cent., but we have never, to my knowledge, accurately measured the efficiency at this point. The velocity of the water when it is entraining the air seems to be about eight feet per second when it is doing its best work, and under those conditions the efficiency, as I say, in the experiments in which I took part, was a little over seventy per cent.

MR. MCKENZIE. What is the method of introducing the air into the water as it passes down?

MR. SHEDD. That has been done in various ways. At Magog it is done by a series of three-quarter inch pipes surrounding a circle, the upper ends above the level of the water and the lower ends at the point of the greatest velocity of the water as it flows into the down-flow pipe. The water passing by the end of the pipe tends to create a vacuum there and the air is drawn in and goes down in bubbles with the water. At Norwich the headpiece is a sort of gridiron with each bar hollow, open on the lower side and supplied with air at the ends, and the water passing down between these gridiron-like bars, the air passes horizontally through the bars into the water as it passes by. There is a plate nearly across the pipe, you might almost call it a pipe, a gridiron bar with a quarter-inch aperture on each side. The headpiece is under three or four feet of water all the time and the pipes to these gridiron bars rise above any possible level of the water in

the headpiece. They are 12-inch pipes with a 36-inch center pipe.

MR. FULLER. I should like to ask Mr. Shedd with regard to the excavating of the well, whether that was expensive? I suppose there was a good deal of water which had accumulated which had to be constantly pumped.

MR. SHEDD. Very little indeed; it was very favorably situated in that respect. Down perhaps one hundred feet there was one seam which developed a pretty good flow of water, but otherwise the ledge was tight. That inflow was taken care of by an excavation in the side of the shaft and a dam between that and the shaft itself, making a well, out of which the water was pumped. We then had no more water to amount to anything until we were at the bottom of the shaft.

MR. FULLER. How much did that excavation cost per cubic yard?

MR. SHEDD. I shall have to tell you from memory, but I think it was $3.50 a cubic yard.

MR. MCKENZIE. Are there any patents on the general process of compressing the air?

MR. SHEDD. Yes. That was patented by a Canadian by the name of Taylor, in England and in this country.

MR. MCKENZIE. Is there a royalty paid?

MR. SHEDD. That I don't know. I don't know what their business arrangement is, but I think the Norwich people are licensed by Mr. Taylor.

MR. SICKMAN. What is the temperature of the exhaust at the engine?

MR. SHEDD. That varies. It is very low in cases. It has been low enough to freeze. We had no difficulty in Magog, but here there has been slight amount of moisture, and the temperature due to expansion is low enough to freeze that moisture unless the air is reheated. But when the air is reheated, which would, of course, be done in all cases if you are seeking economy, then there is no trouble of that sort. There have been a good many experiments made on the temperatures both of the air admitted and the air discharged, but I don't remember the figures. Our experiments showed that from about a third to a half as much moisture

was in the air delivered by the compressor as was in the atmospheric air from which it was drawn; that is, the air has been made dry by being enclosed in water.

MR. T. W. MANN. In 1876, I think it was, I was in Rochester and they had a system of two tubes which were air tight and they let the water in at the bottom and compressed the air in one tube while the water was going out of the other tube, keeping a balance of pressure. I wonder whether that would not be a pretty good way to keep the moisture out.

MR. SHEDD. I don't know, myself, about the process the gentleman speaks of, but I should think it might be very much in theory like a process designed by Mr. Joseph P. Frizell, twenty years or more ago, for compressing air. He had a shaft above a dam down which water went carrying air with it and then he had a horizontal tunnel and a shaft below the dam so that there was a difference of level below and above the dam, and at an intermediate point he had a chamber in which the air was collected. I should think that would be similar to having two pipes. There have been a great many ways of entraining air and compressing it by water, and I think Mr. Frizell's was perhaps the first really practicable scheme. But that never has been put into commercial use, so far as I know, because it was an expensive process as he designed it.

MR. ATKINSON. I happened to be in Liverpool some twenty years ago and went to the great docks, and I found that all the power used there was compressed air. Of course, it would be very dangerous to have fire among the merchandise there. I am not mechanic enough to understand the details of it, but if any of you visit Liverpool I think you will find that the use of air pressure throughout the docks is very extensive. I once gave a hint to a mill man which may be worth the telling here. You all know that the fiber of cotton is exceedingly susceptible to the changes of temperature and humidity. Now, the air which goes down through the wheel pit gets washed and cooled. In the case of the gentleman to whom I refer the basement of his mill was on a level with the tail race, and in hot weather it was very damp and very objectionable. I suggested to him to put an air drum over the water in the wheel pit and to carry the cool, dry air through a pipe into

his picker room and from his picker room into the spinning room, and thus overcome the humidity. He adopted the suggestion and it worked very successfully. That same thing can be done in many places. There is an enormous quantity of air which goes down through the wheels, even without any artificial method of carrying it. I have been told that at a summer resort in Austria a mountain stream has been used to compress air, and one of the show features is to let the cool air out in midsummer and produce an artificial snowstorm. There is a head of about eight hundred feet which gives an enormous pressure.

Our old friend Sam Webber had an entirely new device for compression which he has described to me, and it made such an impression on me as it would naturally make on a "duffer." It was entirely different from Mr. Frizell's, and quite different from the one which was been described to-day. Then, I remember some twenty years ago the Plymouth Cordage Company desired to install an engine for hauling heavy stuff through their yard, and we objected to it. There was then devised an air locomotive and we sent the designs to the Boston Locomotive Works who built it without giving any guaranty that it would be efficient, but that little air engine is operating to-day, carrying around the heavy stock in the yard. When I returned from Liverpool I reported to the Cotton Manufacturers' Association that the English were a generation ahead of us in this country, but we appear to be catching up with them now in the use of air pressure.

THE DIRECT PUMPING METHOD OF WATER SUPPLY IN USE AT TAUNTON, MASS.

BY GEORGE A. KING, SUPERINTENDENT.

[*Read September 15, 1904.*]

When a member of the first board of water commissioners of Taunton, Mass., was seeking some one to take charge of their pumping plant, he expressed the feeling of that time toward the direct pumping system in this way, " We want a man who will make a success of a system which is condemned by every engineer." That was twenty-eight years ago, yet to-day I suppose there is much the same feeling in this part of the country, although the same system is being introduced in large cities under the name " high-pressure system " for fire protection. A plant operated by gas engines and carrying a pressure of three hundred pounds at the pumps has been installed at Philadelphia. New York and Brooklyn have both had the system recommended for them by competent engineers. Bids have recently been received for installing a plant in Brooklyn. Such a plant has been considered for Kansas City, and one has recently been installed at Charleston, S. C.

Thirty years ago the question of a water supply for the city of Taunton, Mass., was under consideration. Taunton was then a city of 21 000 people, but in area the largest city in New England. The population of the section to be supplied with water was estimated at 15 000. The area to be supplied varied in elevation from 5 to 70 feet above mean high water. The highest ground within several miles of the center, where a reservoir might be built, lay three miles to the north, and had an elevation of 200 feet above mean high water.

The feasible sources of supply were the Lakeville ponds, eleven miles to the southeast, and their outlet, the Taunton River, which flowed into the central part of the city from the east. The latter was selected, and a spot two miles east of the center

of the city was chosen as the most available place for taking the supply from the river.

Thirty per cent. of the voters were sure to oppose an expenditure from which they expected to receive no direct benefit. Many of those who could expect to be benefited were so conservative that they would vote against almost any new scheme involving an expenditure. The problem, therefore, was to draw an act to be acceptable to a majority of the voters. The question of the maximum expenditure was a vital one. It was decided to set this at two hundred thousand dollars. Political rather than engineering conditions determined the amount of the appropriation.

The estimates afterward made were as follows:

Reservoir Plan	$479 779.39
Standpipe Plan*	300 850.46
Direct Pumping Plan . . .	249 730.00

Thus it may readily be seen that the direct pumping system was the only one available, or, as stated by the commissioners in their first report, "With our limited appropriation, we could secure water works of greater value to our community by this system than by any other." The plant, with twenty-four miles of distribution mains, was installed for $254 000.

The first pumping plant consisted of a Holly compound engine with four double-acting pumps, constructed so as to be easily detached, so that one or more pumps might be used as desired. The capacity of this engine was 3 000 000 gallons per day. There was a reserve set of two rotary pumps with a capacity of 3 000 000 gallons per day, run by a horizontal high-pressure engine. This made our total pumping capacity at first 6 000 000 gallons per day. The boiler plant consisted of three 60-inch boilers, sixteen feet long.

The plant was started the first of December, 1876, and pumped on an average 360 000 gallons per day.

The daily consumption had increased to 1 000 000 gallons in

*The standpipe location on which the estimate was based would have been entirely unsatisfactory and would have necessitated the use of fire engines at most of our fires.

1891, when a 72-inch boiler and a 4 000 000 gallon Gaskill pumping engine were added.

In 1899 an entirely new boiler plant of four 72-inch boilers, from Edward Kendall & Sons, was installed. These were followed, in 1901, by the addition of a second Gaskill engine with a capacity of 8 000 000 gallons per day. These increases in pumping capacity were not necessitated by the increased consumption, but seemed desirable that we might be prepared for an emergency, such as a disastrous fire occurring during a time of large domestic consumption, when one of the pumps might be undergoing repairs.

Our plant to-day consists of four 72-inch boilers, operated in pairs alternately, using each pair thirty days. The fire under the idle pair is ready for lighting at any moment, although the boilers are not kept filled, as there is less corrosion by keeping them dry. We have a 12-inch steam pipe running from the boilers through the engine room. By this, steam may be taken from either or all of the boilers and delivered to either or all of the engines. We also have an 8-inch auxiliary steam pipe, entirely independent of the 12-inch, which takes steam at will from either boiler to either engine. The pumping plant consists of the Holly quadruplex engine of 3 000 000 gallons capacity, installed in 1876 and still in serviceable condition; the Gaskill cross-compound pumping engine of 4 000 000 gallons capacity, installed in 1891 and usually running from 6 P.M. to 6 A.M. each night; and the Gaskill cross-compound pumping engine of 8 000 000 gallons capacity, installed in 1901, running from 6 A.M. to 6 P.M. each day. We run these Gaskill engines alternately twelve hours each, that we may have a reserve engine always warm and ready for service. Two or more of the engines can be used at once when needed in case of fire or extraordinary consumption. Each engine is connected directly with the supply, and discharges independently into the distributing mains.

There are two 20-inch mains leading by different routes from the station to the center of the city, a distance of nearly two miles. There are now eighty miles of distributing mains, varying in size from 4- to 20-inch. The larger part of the water is carried over a mile from the station in the two 20-inch mains.

There are some branches nearer the station, and at a distance of a mile the branches run in such divergent directions that water is supplied from the station as a center to nearly three fourths of a circle. The most distant point to which water is carried is about five miles from the station. In the opposite direction it is carried about three miles. In lines at right angles to this longest diameter it is carried six miles. In topography this area varies in elevation from 5 to 90 feet above mean high water.

The pumping plant is operated by three shifts of two men each. The steam pressure carried at the boilers is 100 pounds; the water pressure at the gage is, for domestic use, 55 pounds. (The gage is 21 feet above mean high water.) When there is an alarm of fire, the pressure is raised to 100 pounds on the gage, and if the fire is at an elevation where there might be need of increased force, the pressure is raised to 105 or 110 pounds.

The time taken to raise the pressure from domestic to fire is not over three minutes. No fire steamers are used at fires in the district covered by our mains. The pressure needed is always available at the hydrant on the arrival of the hose wagon, saving at least two or three minutes' delay in setting and coupling engine to hydrant and hose to engine when the delay would be most disastrous. The value of time in the early stages of a fire is being more and more appreciated.

In our experience the direct pumping system has worked admirably. It is now nearly twenty-eight years since the pumps were started and they have never failed us. The machinery has been stopped twice. For several hours one night, when the last engine was installed, the pumps were shut down to allow a connection to be made with the steam pipe, and once since for a still shorter time, to repair a valve on the steam pipe. As now equipped, we would not shut down for either cause. There have been breaks in the mains which, until shut out or repaired, have caused the pressure to be greatly reduced, and when we had but one main leading to the center, a break in this entirely cut off the supply from the city.

If " the efficiency of a water works is measured by its ability to control a bad fire before it becomes a sweeping conflagration," as Mr. J. R. Freeman has said, then the direct pumping system,

as used in Taunton, has proved its efficiency in its twenty-eight years of service. It has never failed to be ready, and any deficiency has been clearly shown to be due to small mains and not to the pumping system. My predecessor as superintendent, Mr. George F. Chace, in a paper before this Association in 1891,* gave in detail the work done at numerous fires, and the record has been fully maintained up to this time. On the 16th of last month (August), at 1.27 A.M., in a stable and in a near-by laundry, was discovered a fire under good headway, so much so that nothing was rescued from the stable, and but little from the laundry. These buildings were surrounded by others but a few feet away. The fire was confined to the two buildings, controlled by eighteen good streams with first-class pressure. We pumped about 1½ million gallons between midnight and six o'clock the next morning; this was pumped part of the time at the rate of 8 000 000 gallons per day.

The total expense at our pumping station last year was $9 363.78. The chief engineer of our fire department tells me that if he had to use steamers to obtain the necessary fire pressure, as he undoubtedly would under any other system, the extra annual cost of his department would be about $25 000.

Mr. George A. Ellis, in a paper before this Association, said, "If the pipe system is well designed, able to convey the volume of water required without undue loss from friction, and the pipe itself able to withstand the strains and shocks arising from direct pressure, then direct pressure is desirable for fire protection." We have experienced no shocks and apparently no strains, except what would be produced under any system with equal pressure.

There is some indication that others are coming to be of the same opinion as Mr. J. N. Tubbs, of Rochester, N. Y., was thirteen years ago, when he said, "As a device for the suppression of fires, I believe it to be unequaled, and I am inclined to the opinion that the general adoption of this or some similar system in all large cities and manufacturing towns where valuable buildings, merchandise and industries are concentrated, will be found the most effective and cheap means for fire protection."

*JOURNAL, N. E. W. W. Assn., Vol. 6, p. 67.

DISCUSSION.

MR. FRANK E. MERRILL. I should like to ask Mr. King what effect the increase from domestic to fire pressure has upon the plumbing in the houses.

MR. KING. The tanks of the water-closets have frequently caused trouble on account of leaking because of the increased pressure. When the pressure goes up to fire pressure, the valves which have been set to work on 55 pounds will frequently leak.

MR. MERRILL. Is the city metered?

MR. KING. About forty per cent.

MR. MERRILL. And on account of the waste from the ball cocks occasioned by the increase of pressure, do you not sometimes have complaints from the consumers because of the extra amount of water which passes through?

MR. KING. We do have plenty of them.

HASKELL'S BROOK RESERVOIR AND DAM, GLOUCESTER, MASS.

BY H. W. SPOONER, CIVIL ENGINEER, GLOUCESTER, MASS.

[*Read September 15, 1904.*]

The city of Gloucester has a system of water works which has an interesting history. The writer will not attempt, however, to give details at this time of the ways and means which were utilized to supply this old and beautiful Massachusetts locality with water for domestic and other purposes, but will endeavor to describe only the construction of the new impounding reservoir, the preparation of the basin, and the building of the dam.

The original plant was constructed by George H. Norman and owned by the Gloucester Water Supply Company. This company contracted with the city to furnish fire protection, etc., under contracts which were to expire in 1896, previous to which time, however, the city acquired possession of the works, and it was necessary to immediately commence improvements and additions.

By referring to a schedule prepared by the writer, — Plate I, showing the number of gallons of water pumped since the first record was kept, — and remembering the fact that the estimated average daily yield of both sources originally acquired by the city is about 900 000 gallons, one may readily perceive that even previous to the time that the city obtained possession of the works, a further or added source of supply was necessary in case of exceeding dry weather. On account of the slight depth and the nature of the bottom of the Wallace Brook Reservoir, the water from that source is not fit for use during the warm season, and the only supply at the disposal of the city which could be depended upon for use throughout the year was the Dikes Meadow Reservoir.

From the second annual report of the board, the following quotation is taken: " The supply of water has been sufficient

for our needs this year, but we recognize the fact . . . that we shall need an increased supply."

From the report of 1898 it may be seen that although extensive changes were made at the pumping station, no beginning was made upon an additional supply.

In the report for the following year, a report of Engineer Percy M. Blake may be found, in which he discusses an additional supply from either of two sources — one being the Chebacco Lakes, the other Haskell's Brook.

During the year 1900 the writer, at the request of the water board, made a survey of the Haskell's Brook watershed, commenced surveys for the definite location of an impounding reservoir in the valley through which the brook flows, and made a report of his findings.

In 1901 the city council voted an amount of money for additional water supply, and the water board decided to utilize Haskell's Brook by erecting a dam across the valley three thousand feet or more above the site of an ancient sawmill, impounding the waters of the brook and conducting them to the pumping station by a gravity conduit composed of 20-inch cast-iron pipe.

Early in July an engineer corps was organized, and under instructions from the board surveys were recommenced, and in September plans of all lands affected by the construction of the proposed reservoir were laid before the commissioners.

After considering the matter at length, the board decided to " take," by right of eminent domain, all properties within the lines laid down and necessary to the project, the required plans and papers were filed, and the work of clearing and preparing the basin for the storage of an additional supply of water for domestic and other uses was commenced under the personal direction of the writer on October 30, 1901. It was the intention of the board to do the work upon this basin by day labor, and the removal of timber, brush burning, etc., was done by citizens of Gloucester, the wage rate being two dollars per day of eight hours.

A location for the site of the basin was chosen in a portion of the valley upon the east side of which the earth was of gravel and ledge, having a very slight coating of loam; upon the west

DIAGRAM SHOWING

CONSUMPTION OF WATER AS INDICATED BY THE RECORDS OF PUMPING

GLOUCESTER WATER WORKS

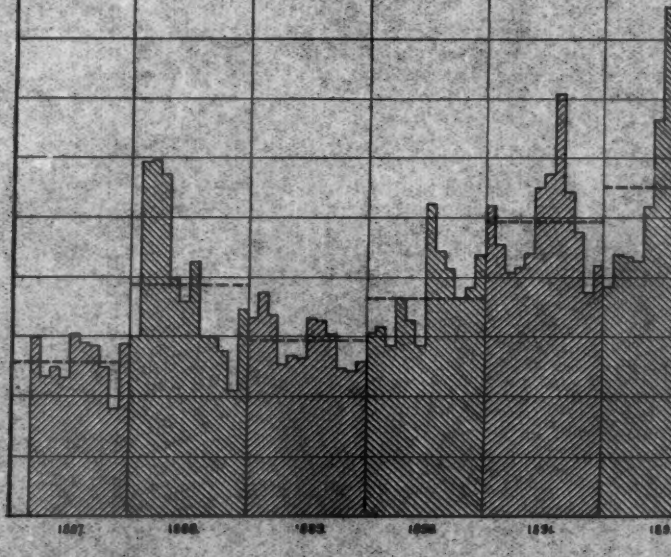
GLOUCESTER, MASS. JANUARY, 1904.

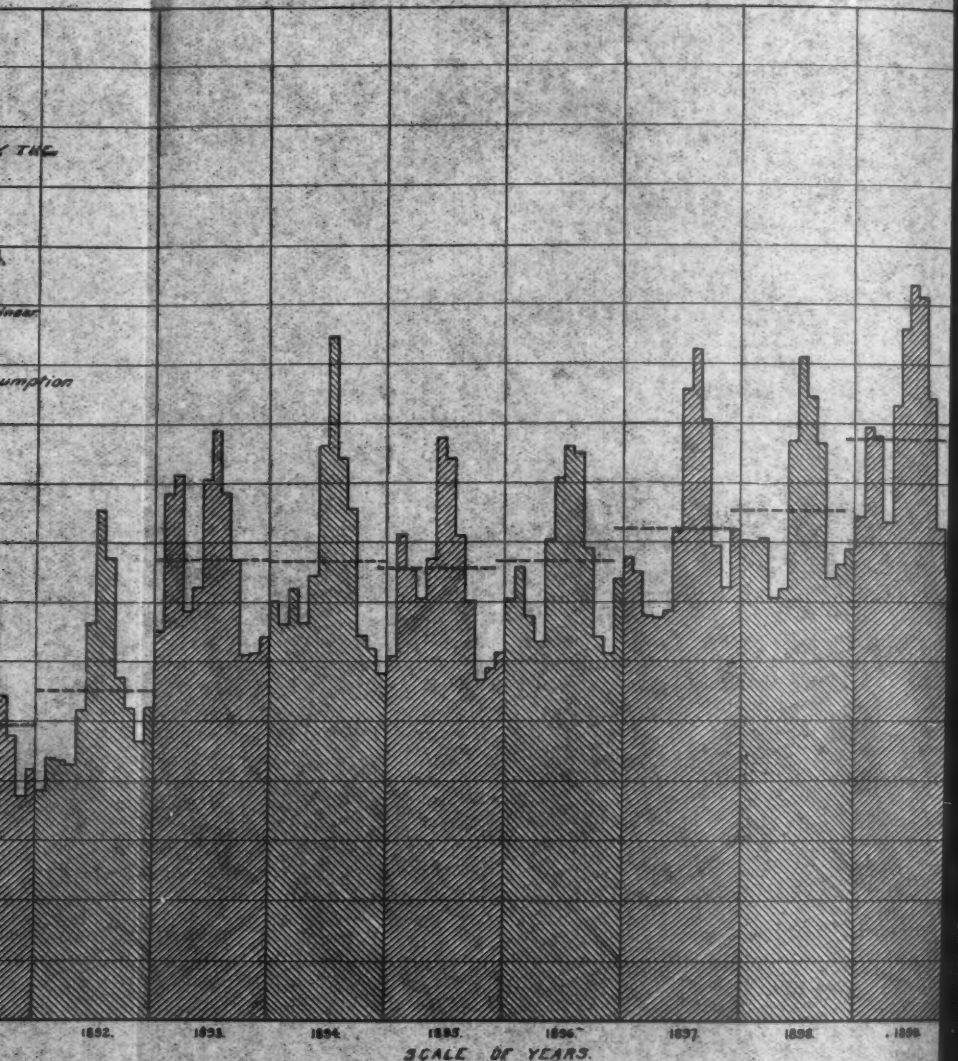
William M. Farnum, Engineer.

Note— No record was kept prior to Mar. 1, 1887.

Double broken lines indicate average daily consumption for period of one year as shown.

A Diagram to accompany annual report (1903)

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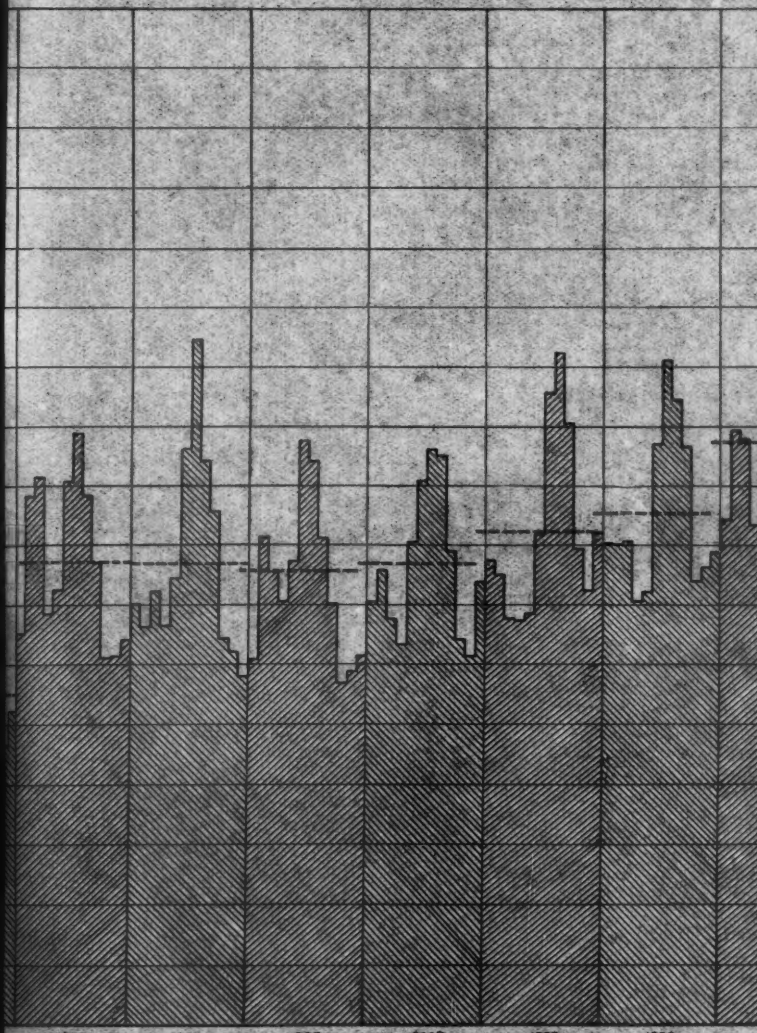
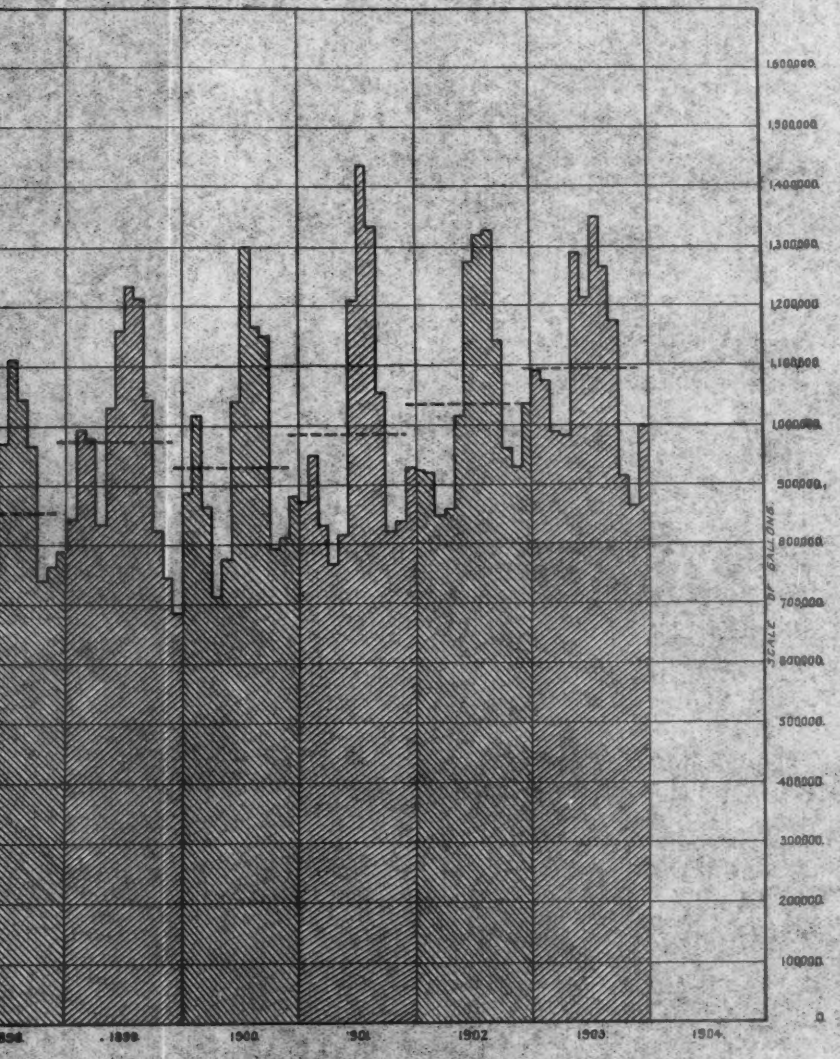
SCALE OF YEARS.



SCALE OF YEARS.

PLATE I.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SCALE OF GALLONS
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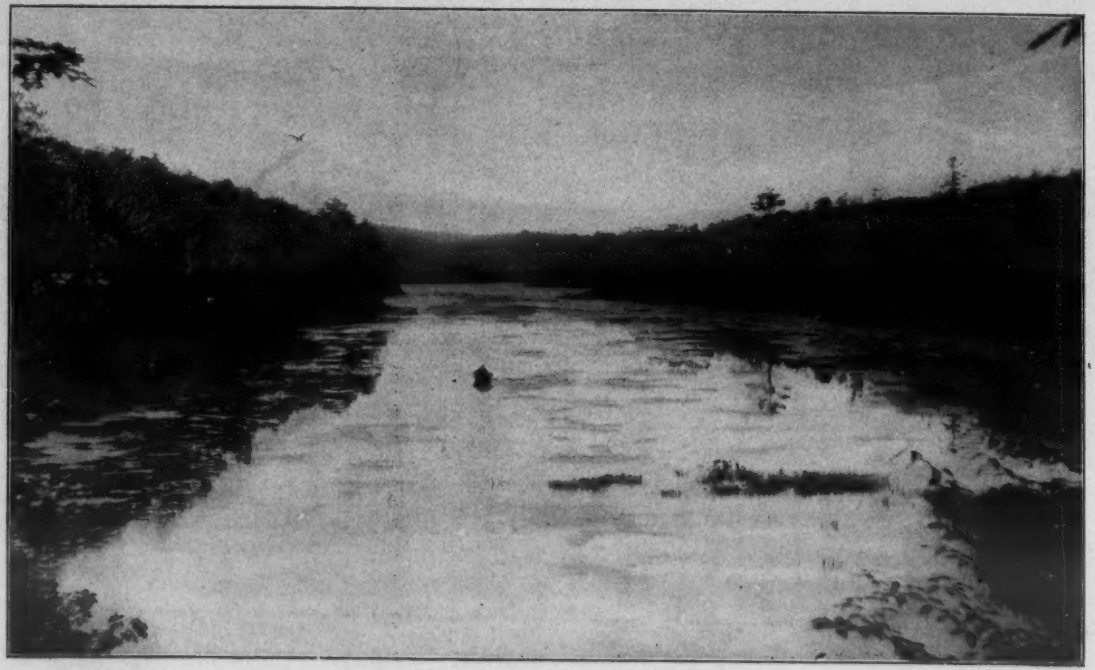
1904



HASKELL POND, LOOKING SOUTH FROM TOP OF "SUGAR LOAF," NEAR ORIGINAL DAM, — Sept. 9, 1901.

PLATE II.

side, disintegrated ledges and bowlders and a very little gravel were found. The hills rose abruptly from the edges of the ancient pond (Plate II), the waters of which (having a maximum depth of four feet) were formerly impounded and used by the owners of a sawmill which was situated some distance below on the line of the brook.

After the pond, which had an area of about twenty-six acres, was drained and the obstructions removed from the brook bed, it was found that the silt had accumulated for centuries in the bottom of the valley, leaving the bottom of the pond practically level, with a maximum known depth of silt, vegetable matter, etc., of sixteen feet. As the watershed above this site is entirely free from dwellings of any description and practically free from large, swampy areas, it was decided that by careful work upon the basin proper, water of excellent quality could be obtained from this source.

The removal of wood was practically completed prior to the opening of the spring of 1902, at which time the writer began detailed operations upon the proposed dam site, and the preparation of the bottom of the basin was placed in charge of Superintendent John W. Moran.

As it was found that, on account of the excessive depth of silt, it would be impracticable to remove it from the basin, borrow pits were opened in the sides, and the work of covering the entire reservoir bottom, an area of about twenty-six acres, with clean earth was commenced in 1902, citizens of the city only being employed at the rate above-mentioned to do this portion of the work, which was completed in September, 1902, the depth of cover averaging about one foot.

While the above work was being carried forward, the sides of the reservoir were grubbed, the stumps removed, and a small roadway constructed across a shallow arm of the pond on the east side. This roadway was one of the original ways to the wooded properties beyond the pond, and, as constructed, the waters collected in this shallow portion of the reservoir are held, the water passing from the surface of this section of the basin to the main reservoir in freshet season through a culvert near the surface of the roadway.

The plans for the construction of the main dam were completed, a contract and specifications prepared, and bids called for by the writer under direction of the water board. On the opening of the bids, the contract was awarded to Coleman Brothers of Everett, Mass.

This work was commenced on July 23, 1902, and completed on August 8, 1903, the reservoir containing at the time of the completion of the structure a maximum depth of water of 20.17 feet.

The work was commenced by stripping the site of the dam of all loose bowlders and muck, and excavations were begun for the core wall, gate-chamber, and gate-house foundation. These excavations were extended to ledge or a suitable bed of hard pan upon which the concrete work was laid. The trench for the core wall foundation (Plate III) was opened entirely across the valley, and the concrete wall was constructed in layers of from three to four feet in depth, the top of each stratum being grooved by the use of a piece of timber eight inches square embedded in the concrete when placed. After the concrete was set, these timbers were removed, leaving an indentation which was filled with cement just prior to laying the succeeding course. The entire work was carried up in layers which reached across the valley (Plate IV), the earth forming the embankments being spread about one foot in depth, then rolled and puddled. The slope toward the pond was paved. The gates in the gate-chamber were set in place as the grade of each was reached. The work was carried up in this way (the valley sealed for its entire width) so that as much water as possible might be stored in the basin at the earliest possible date.

Large quantities of the material used in forming the embankments were taken from borrow pits situated inside the basin, a pit being opened on the outside when, on account of the rising of the waters, the inside pit could no longer be utilized.

The stone used in the concrete was crushed upon the work; all bowlders removed from the site of the dam were hauled out upon the pond bottom, broken up and delivered to the crusher, and, later, stone from the pits was utilized. As no suitable sand was found near the site of the work, the contractors were obliged

PLATE III.

VIEW LOOKING WEST, SHOWING CORE WALL TRENCH AND FIRST CONCRETE WORK. — Sept. 11, 1902.

Looking East Along Dam, Showing Core Wall, 20-inch Pipe, and Gate Chamber Commenced. — Oct. 10, 1902.

Plate IV.

to haul all that was used from a pit some three quarters of a mile distant.

The dam, built in strict accordance with the original design, is what is known as an earthen core-wall structure, a core of concrete being erected in the center of an earthen bank throughout its length, the top being two and one-half feet above the normal flow line of the reservoir.

Within the basin and rising through the embankment about half way up the inner slope, a circular gate-chamber, fifteen feet in interior diameter, built of concrete and lined with brick, was constructed (see Plates V and VI). Wing walls project from this chamber to the outer lines of the embankment, forming an open passage five feet in width at the bottom of the chamber; in the bottom of this passage is the blow-off or scouring pipe and the lower end of the twenty-inch automatic overflow pipe.

The intakes consist of cast-iron pipes set in the concrete walls, six feet apart vertically, and upon different sides of the chamber. On the inside of the tower and bolted to the flanged ends of the intake pipes are the gates, which are of the adjustable pattern of sluice-gate made by the Coffin Valve Company. These gates are operated in the brick superstructure which surmounts the chamber by wheel stands connected with the gates by two-inch steel rods. Within the chamber, brick walls project inward from the lining, into which iron screenways are built; screens of copper wire, with hard-pine interlocking frames which were furnished by the Coffin Valve Company, are operated in the screenways, and may be removed and cleaned at will.

A gate-house of brick, built outside of and below the dam, contains the gate valves that are located upon the delivery main, scouring pipe, and by-pass. This last valve is used when the gate-chamber is cleared or water withdrawn for repairs, allowing the delivery main to remain full below the gate-house, the by-pass making a cross connection between the delivery main and scouring pipe.

The automatic overflow before mentioned was introduced into the work at the suggestion of Mr. William Wheeler, civil engineer, of Boston, who served as consulting engineer upon this work. It consists of a line of 20-inch Akron pipe laid from the bottom

of the passage before mentioned, under the paved inner slope of the dam to the wasteway, and there discharging the waters from the bottom of the basin when the water reaches the normal flow line. It will be observed, therefore, that the normal waste of water from this reservoir is from the bottom, the water of poorest quality being wasted with the aid of this device, while the better quality of water near the top of the reservoir is taken for use through the intake which is nearest the surface.

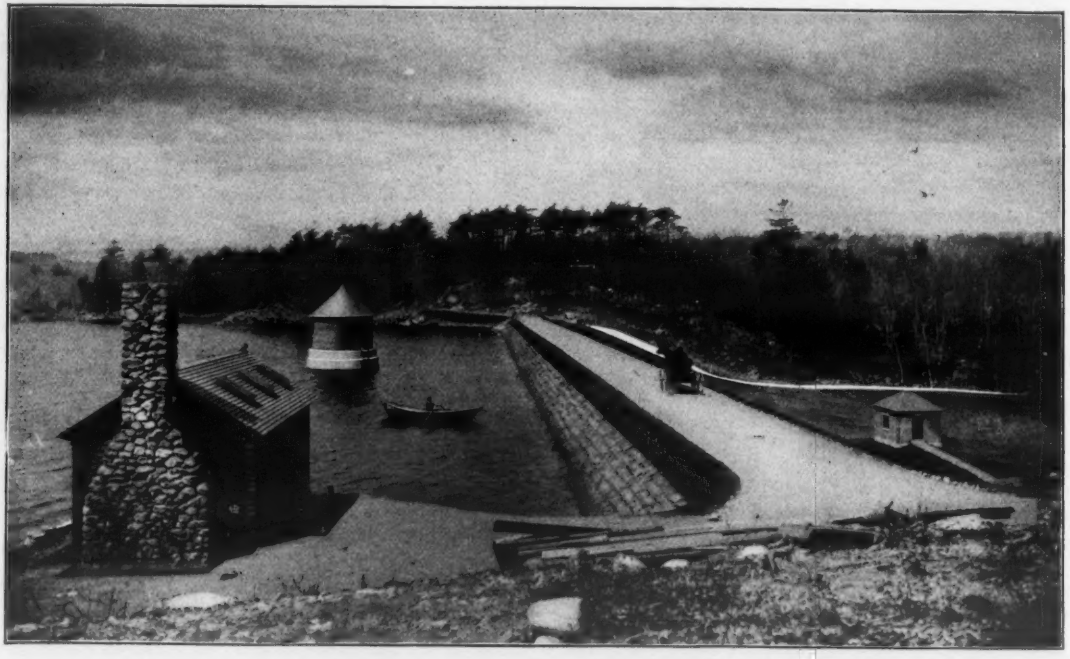
The wasteway is fifteen feet in width, the waste waters being conducted to the original brook bed below the dam by a paved way, the paving of which is laid in cement.

The inner slope (2 and 2½ to 1) of the structure is paved with granite blocks, while the outer slope (2 and 2½ to 1) is grassed. A roadway extends along the entire top of the structure (Plate VI), connecting the original wood roads on either side of the valley.

The reservoir is about one mile in length and covers about 57 acres, the watershed containing about 325 acres. The basin contains at the normal flow line about 427 000 000 gallons, having a maximum depth of 37 feet, the average depth being 23.06 feet. The above capacity may be increased (in fact, the water level is at present above the normal flow line) by the use of flashboards at the wasteway, the possible increase being about 48 500 000 gallons.

Plate V.

Gate Chamber under Construction, Showing Blow-off Gallery, Concrete Work, Brick Lining, and Inlet Pipe at Elev. 87. — Nov. 1, 1902.



Completed Dam, Looking West. — Aug. 19, 1903.

Plate VI.

DESCRIPTION OF CONCRETE-STEEL WATER TOWER AND STANDPIPE AT FORT REVERE, HULL, MASS.

BY LEONARD S. DOTEN, CIVIL ENGINEER, QUARTERMASTER'S DEPARTMENT, UNITED STATES ARMY, BOSTON, MASS.

[*Read December 14, 1904.*]

Whether one enters Boston Harbor from the open sea or sails down the channel towards Boston Light, the most conspicuous landmark which attracts the eye is the tower-like structure standing on the summit of Telegraph Hill in Hull. This is the concrete water tower constructed by the government in connection with the water-supply system for the military post known as Fort Revere, and situated at an elevation of one hundred and thirty feet above the sea level. Its advantage of position not only affords good water pressure in the military post water mains, but also makes it a landmark which is often used by navigators at sea for determining their position as they approach the coast. Additional interest is attached to its location from the fact that it is built on one of the bastions of a Revolutionary fort, commonly known as " the old French fort." It is a unique engineering structure, having been erected at a time when reinforced concrete construction in this country was in its early stage of development, and has the distinction of being the first water tower in this country constructed of this material.

Plans and specifications had been prepared in the Boston office of the quartermaster's department, United States Army, in the spring of 1902, for a tower to enclose the steel standpipe which the department proposed to erect in connection with a water works system for the fort. Its purpose, on account of its proximity to the fine residences of the town and its conspicuous location, was twofold, — to protect the standpipe against possible destruction by the formation of ice cores during the winter, and to add an interesting feature to the landscape, rather than a

disfigurement. The design, however, was later considerably modified to lessen the cost of construction.

In May, 1902, the department advertised for proposals for the construction of the tower. According to the instructions given to bidders, contractors were allowed to submit proposals for either a brick masonry tower or a stone masonry tower of the same general design. There was also a further provision allowing a contractor to submit a proposal for the construction of a tower and standpipe from his own plans and specifications, the standpipe to be of the same dimensions as those given in the plans prepared in the quartermaster's department. The proposal finally accepted was that of Mr. R. Baffrey of New York City, which was based on the construction of a concrete-steel tower and standpipe designed in accordance with the Hennebique system of armored concrete.

The authorization for the building of a structure so radically at variance with the best engineering practice at that time, by a department of the government known to be conservative in its methods, could only be accounted for by the fact that it desired by means of experiment to find a material more durable and economical in maintenance than steel for standpipe construction. The annual cost of maintenance of steel standpipes and similar structures is an important factor to be considered by any corporation. This is especially true when they are located along the seacoast and in tropical climates. Therefore the conclusion was reached that if concrete standpipes could be constructed which would prove satisfactory structurally, the solution of the problem was found.

Work was begun on the tower in the latter part of June, 1902. The concrete work was completed that fall, but the tower was not fully completed and accepted until June, 1903. Water was turned on late in the fall of 1902, and the standpipe was filled for the purpose of testing it. So far as the concrete was concerned, the test was satisfactory, but it was necessary to draw off the water in order to repair some leaks which developed around the inlet pipe connection and around the iron manhole cover. The defects were easily remedied. During the remainder of the winter the pumping was so regulated as to keep the standpipe

PLATE I.

CONCRETE-STEEL WATER TOWER AT FORT REVERE.

about one third full, for above that height there was no protection from the frost, as the brick panels in the walls of the tower were not in place. Since the tower was completed and accepted, in June, 1903, it has been in constant use and has given perfect satisfaction. It has never leaked, nor has there been any indication of seepage through the walls.

The tower is octagonal in form, 33 feet in width at the base and 84 feet in height, measured from the grade line of the base to the apex of the steep pyramidal roof which surmounts the structure. It is constructed principally of reinforced concrete. The massive base, the eight columns supporting the superstructure above the standpipe, the floor and walls of the observatory, and the winding stairs extending from the entrance of the tower to the observatory, are all constructed of this material. The deeply recessed panels between the columns are formed of buff-colored pressed bricks. The roof structure, which is of wood, rises eighteen feet above the masonry of the tower and is covered with black slate. The character of the architectural design, assisted by the harmonious colors of the concrete and brick walls, makes the tower an attractive feature in the landscape. (See Plate I.)

The foundation of the tower is constructed of concrete composed of one part Portland cement, three parts sand, and five parts broken stone. As the soil on which the foundation was to rest was of a firm, unyielding nature, locally known as "hard-pan," it was not deemed necessary to place it lower than would be required to insure it against the action of frost. The depth of concrete below the finished grade is five feet. A portion of the foundation is taken up by a valve chamber, 5 feet by 9 feet in plan and 6 feet in height. The walls of this chamber extend two feet below the bottom of the other portion of the substructure, and they are reinforced with $\frac{3}{4}$-inch steel rods. This chamber contains the 6-inch inlet and outlet pipe, the 6-inch drain pipe, and the two gate-valves controlling these pipe lines. Fig. 1 shows an elevation and section of the tower and tank.

The concrete base of the tower is 4 feet thick at the grade line, and for a height of 4 feet the inner and outer surfaces are vertical. Above this point it batters on the outside to a thickness of 2 feet

at an elevation of 11 feet above grade. The concrete base is terminated at the top by a belt course 2 feet in thickness and

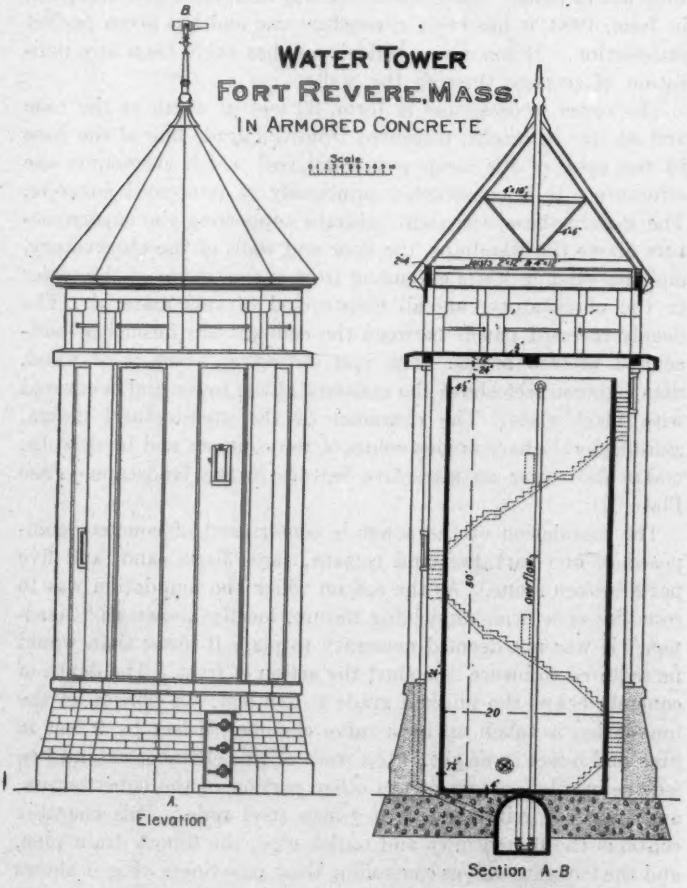


FIG. 1.

projecting 15 inches beyond the outer face of the base. The external face of the base is divided into rectangles by deep grooves,

which give it the appearance of regular coursed ashlar masonry. The concrete forming this portion of the tower is reinforced by ¼-inch steel rods and stirrups.

Resting on this base as a foundation are eight reinforced concrete columns 38 feet in height, which support the upper portion of the tower and roof. These columns are 3 feet 6 inches wide on the external face, and 3 feet on the internal face, and 2 feet thick. They are each reinforced by six 1-inch vertical rods extending the entire length of the columns.

The spaces between the columns are filled with 8-inch walls laid with buff-colored pressed face brick. Capping the columns and brickwork panels is a massive coping of reinforced concrete, which overhangs the columns on the exterior two feet, and forms the support for the concrete floor of the observatory.

Immediately above the main columns of the tower, and rising six feet above the floor of the observatory, are smaller columns which support the roof. The spaces between the columns are left open, with the exception of a 2½-inch galvanized iron bar across each, about 2½ feet above the floor.

The concrete floor of the observatory is 3½ inches in thickness. It is reinforced by ½-inch rods and supported by two 8 × 16-inch reinforced concrete girders, which are 8 feet apart. The floor was designed to carry 60 pounds per square foot.

The roof was strongly constructed of spruce timber and sheathed with dressed tongued and grooved boards. The slate used were the best quality of unfading black, and were secured to the sheathing with copper nails. The cornice, finial, and weather vane were formed of heavy galvanized iron.

The stairway, which almost completely encircles the standpipe, extending from its base nearly to the top, is also of concrete-steel construction. Small platforms anchored to the main columns of the tower at regular intervals form the supports for straight flights of stairs connecting them. The stairway does not come in contact with the standpipe at any point.

The most unique feature of the entire structure, and unprecedented in the nature of its construction in this country, is the concrete standpipe, some details of which are shown in Fig. 2. It is 20 feet in internal diameter and 50 feet in height, having,

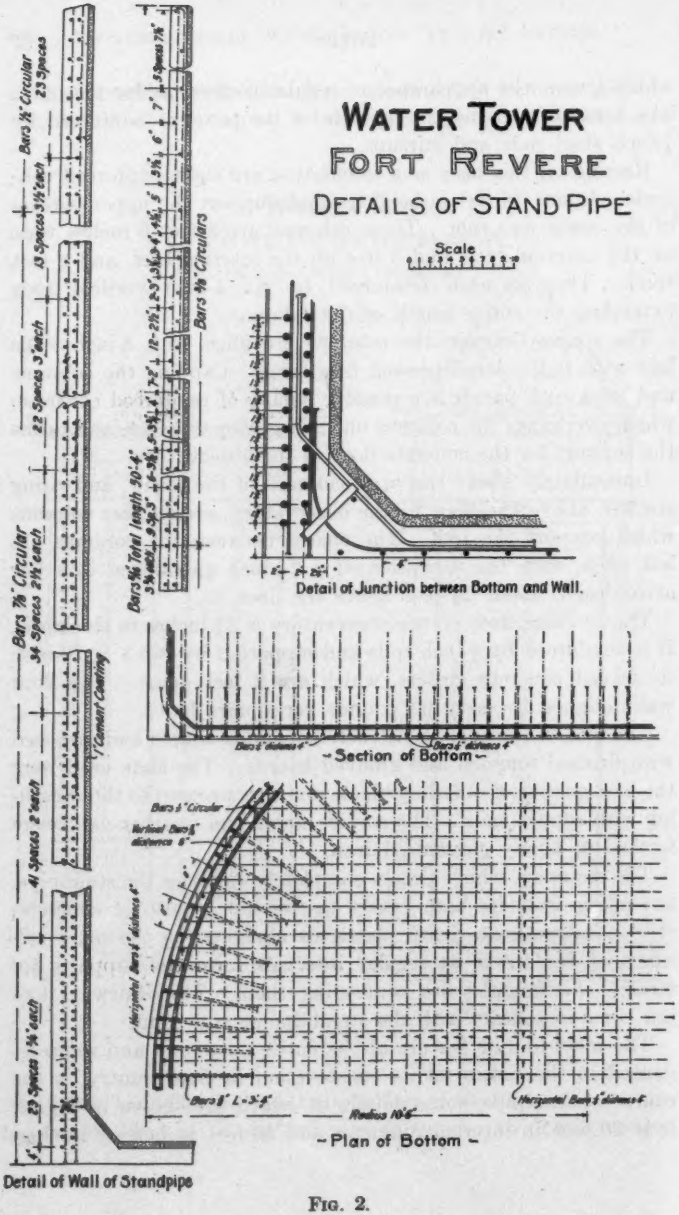

WATER TOWER
FORT REVERE
DETAILS OF STAND PIPE
Scale
Detail of Junction between Bottom and Wall.
Bars ⅞" Circular
34 Spaces 2½" each
41 Spaces 2" each
23 Spaces 1¼" each
Bars ⅞" Circular
23 Spaces
13 Spaces
22 Spaces 3" each
Bars ⅝" Circulars
Bars ⅝" Total length 50'-4"
Cement Coating
Detail of Wall of Standpipe
Bars ⅝" Circular
Vertical Bars ⅝" distance 6"
Horizontal Bars ⅝" distance 6"
Bars ⅝" L-3'-6"
Radius 10'-6"
Horizontal Bars ⅝" distance 6"
- Section of Bottom -
- Plan of Bottom -

FIG. 2.

therefore, a capacity of approximately 118 000 gallons. The walls of the standpipe are formed of a thin shell of concrete, 6¼ inches in thickness at the base and 3¼ inches at the top, in which is embedded a complex system of steel rods. The interior surfaces of the standpipe were later made smooth and impervious by applying to them three coats of Portland cement plaster, this waterproofing having a uniform thickness of one inch.

The inner form was first placed in position. It consisted of four horizontal rings of equal heights placed one above the other, each being divided into eight equal segments formed of plank ribs and vertical lagging. The whole inner form was rigidly braced and tied together inside. The outer form was so constructed that it served a double purpose, being also used for a scaffold in placing material. Uprights were placed radially in two circles about four feet apart on the inner one. These were firmly held in position by braces, the inner circle being properly adjusted with reference to the inner form to give the required thickness of concrete at all elevations. After the rods were placed in position, ½-inch boards were bent horizontally until they formed a true circle in contact with the inner faces of the uprights. These were placed or driven into position a little in advance of the concrete filling.

Portland cement concrete, mixed in the proportion of one part cement, two parts sharp sand, and four parts coarse gravel, not over one inch in diameter, was deposited between the forms and worked around the rods in such a manner as to leave no voids. The reinforcement of the walls of the standpipe consists of horizontal rods in the form of rings, and vertical rods. In the lower portions of the standpipe the horizontal rods are ½-inch in diameter, and when placed in position formed two concentric rings in each plane. At the base the vertical distance between the planes was 1¾ inches. This interval was gradually increased toward the top until the final intervals were 7½ inches. The vertical rods were $\frac{5}{16}$ inch in diameter, and placed 8 inches on centers and wired to the horizontal rods at each point of contact. They were placed in such a manner that one half of the rods were in contact with the inner rings and the other rods with the outer rings.

In the bottom were embedded two systems of rods, placed at right angles to each other and wired together at all intersections. These rods were ¼ inch in diameter and placed 4 inches on centers. The angle between the bottom and sides was also reinforced with ⅜-inch rods, 3 feet 4 inches in length and placed radially, these being about 8 inches on centers at sides.

The standpipe is provided with an outside overflow pipe extending from a point one foot from the top to a junction with the drain pipe in the valve chamber. It is a 6-inch wrought-iron pipe and is provided with an expansion joint.

The erection of this standpipe has been a successful experiment, and has demonstrated the adaptability of concrete-steel as a material for structures of this class, when it is properly handled. This form of construction, in its marvellously rapid development in this country, is a subject in which water-works engineers are becoming deeply interested. It possesses great possibilities in such structures as dams, reservoirs, filter beds, aqueducts, standpipes and water mains, but many failures must necessarily follow its use along these lines through faulty designs or the inexperience of those in charge of construction.

DISCUSSION.

MR. EDWARD ATKINSON. I should like to ask if the floor stresses and lateral stresses are carried entirely by the steel, or if any reliance is placed upon the concrete?

MR. DOTEN. The floor stresses are carried by the concrete base. It is a very thick mass of concrete, and it is reinforced by small rods, not so much for strength, perhaps, as to prevent cracks at the surface from the contraction of the concrete. The walls are entirely dependent upon the steel reinforcement; no dependence at all is placed upon the concrete for tensile strength.

MR. ATKINSON. I find that the most conservative engineers are inclined to the belief that all the stresses, except of thick masses of concrete for vertical stress, should be carried wholly by the steel, and the concrete is merely a protective covering and to support the steel.

A MEMBER. Will you state the cost?

MR. DOTEN. The water tower and standpipe complete cost $11 980.

MR. F. I. WINSLOW. Will you please state where the water supply is obtained for the standpipe?

MR. DOTEN. It has been taken from a driven well on the Reservation, but that has not proved altogether satisfactory, and I believe the department is planning to take the water from the Hingham system.

MR. DESMOND FITZGERALD. How much space is there between the inner shell and the outside?

MR. DOTEN. About two feet. Of course the tank is circular in form, and the tower is octagonal; about two feet is the least space.

MR. A. O. DOANE. Has any trouble been experienced from freezing and ice pressures?

MR. DOTEN. The tower, of course, is intended to protect the standpipe from the frost, but accidentally last winter the standpipe was left full of water during the coldest period, and was shut off from the system for a short time, — three or four days; and I understand from the commanding officer that about three inches of ice formed on top of the water. There has not been any heavy mass of ice.

MR. DOANE. I should think in case any heavy ice formed, as it does in steel standpipes very often in our New England climate, it would be very injurious to such a structure as this. There is a certain amount of elasticity in steel which such a structure as this lacks.

MR. DOTEN. I do not think there is much more danger from ice in a concrete standpipe than there is in a steel one. You can very definitely determine how much steel is required in such a structure as this to resist certain pressures, and quite as well as you can in the case of a steel structure.

MR. HORACE G. HOLDEN. How did the cost of this compare with an ordinary steel standpipe?

MR. DOTEN. This one was somewhat cheaper. I could not say as to all sizes, for it depends somewhat on the conditions and size of the standpipe; but generally I should say that the type would be cheaper than steel.

MR. CHARLES N. TAYLOR. Is it considered necessary to have this outside covering? Would it not be all right, if it were not for the appearance, to have the standpipe without the tower, the same as if it were of steel? Of course with a steel pipe you wouldn't ordinarily have any such outside covering as you have there.

MR. DOTEN. I do not think it is necessary to have a tower enclosing the standpipe. The original idea was to have an ornament on the hill rather than a disfigurement. The contractor who constructed it did not think it was necessary to have any protecting tower, but it was merely a requirement imposed by the government.

MR. TAYLOR. Wasn't the largest part of the expense in building the enclosing tower?

MR. DOTEN. Yes, sir.

MR. TAYLOR. In your opinion, what would the cost of the standpipe itself have been if you had left out the outside part of it? Should you say it would have been less than half?

MR. DOTEN. Oh, yes, indeed; I should suppose, possibly, $4 000.

MR. TAYLOR. And you think that that would have withstood the action of frost equally as well as steel if it had no protection?

MR. DOTEN. Yes, if it had been designed with that in view. Of course we knew it was to be enclosed; perhaps it might have been more heavily reinforced if the standpipe had been designed to be exposed.

METER RATES.

[Topical Discussion, November 9, 1904.]

PRESIDENT BROOKS. The report of the Committee on Meter Rates is now in order.

MR. CALEB M. SAVILLE.* If I am the only member of the committee present, Mr. President, all that I can report is that your committee is working on the subject, and we hope before long to be able to present something for your consideration.

THE PRESIDENT. Has Mr. Merrill anything to say?

MR. FRANK E. MERRILL.† I will say, Mr. President, that my associate on the committee, Mr. Saville, has covered the ground thoroughly in his report. (Laughter.) I would suggest, however, that instead of the report of the committee, you ask for suggestions from members of the Association, and I am sure that anything in that line will be thankfully received by the committee.

THE PRESIDENT. Following the suggestion of Mr. Merrill, I would say that if there is any one present who has any idea to express in regard to what should be embodied in the report of the Committee on Meter Rates, we should be glad to hear from him.

MR. HUGH MCLEAN.‡ This matter of a standard metered price to all users of water is something that I have given considerable thought to, and I hoped that there would be some report made to-day that would give me some light on the subject.

My idea is that all metered water should be charged to all parties at the same price; that all consumers of water should be charged so much per thousand gallons, whether they use a million gallons or a thousand gallons. In our city of Holyoke, if the monthly consumption is 50 000 gallons or less, the rate per 1 000 gallons is 12 cents net; for a monthly consumption in excess

* Division Engineer, Metropolitan Water Works, Boston, Mass.
† Water Commissioner, Somerville, Mass.
‡ Member Water Board, Holyoke, Mass.

of 50 000 gallons, and not exceeding 200 000 gallons, the rate is 8 cents net; and if the amount used per month is in excess of 200 000 gallons, the rate per 1 000 gallons is 4 cents net. Now, I contend that this is wrong. Other members of the Association may not agree with me, but following up the argument presented by Mr. Tighe in his paper at the Holyoke convention on assessing values of municipal ownership in water departments, it seems to me that the equalization of meter rates is a problem worthy of the attention of this organization.

I contend it is the duty of the municipality to sell water to all its citizens at the same price, and that the sooner a uniform charge per 1 000 gallons is adopted by a water department, the better and the more satisfactory it will be to all the citizens.

I might cite to you the fact that the present system encourages concentration of capital to the disadvantage of the individual. I might cite to you the fact that a large number of men may get together and call themselves a company, and by consuming a large amount of water, get it at the low rate. I can cite as a fact that this thing is being done in some cities in New England, and the only way to obviate it, and to make the cost of water the same to all, is to have a uniform rate of charge to every citizen. It may not be possible to have the same rate in all cities, but in every city there should be a uniform rate to all consumers. For instance, take the American Writing Paper Company in Holyoke, since the amalgamation of the paper interests called " the combine "; previous to that amalgamation the water for each mill was metered and each paid for its own water. Take the American Thread Company; previous to the amalgamation of all the thread interests, each mill paid for its own water. Now, by using a great quantity of water, they get it at the low rate of 4 cents per 1 000 gallons.

Now, what is to prevent similar amalgamations of interests in other cases? For instance, all the users of water for elevators in a city may get together and call themselves the American Elevator Company, and own all the elevators and have the water all charged to the American Elevator Company, thereby robbing the department to the detriment of the small user of water. You are expending annually large sums of money in building

up water works, and you are giving the advantage to the large users of water. That evil, it seems to me, should be corrected by the adoption of a uniform system of charges for water to all consumers, say 4 cents per 1 000 gallons, or whatever is actually necessary to bring the receipts up to the present revenue, — even if the rates have to be overhauled, which may be necessary in order to treat all citizens alike. All citizens are equal owners in the water department, — I refer now to water departments under municipal ownership, and this may not apply to private ownership, — and being equal shareholders in the plant, all are entitled to the same treatment. The United States government does not sell stamps to one man for a less price than it does to another. A man who buys $1 000 worth or $10 000 worth of stamps pays at the same rate as the man who buys only one stamp; and the same treatment ought to be accorded to all citizens who use the public water supply.

And for further proof of my statement, I will cite to you the fact that the municipal lighting department of Holyoke, which has lately acquired a plant from private ownership, charged for lighting on a basis of rates similar to those that are now charged for water, which I think is entirely wrong. If a man used $100 worth of electricity in a month, he got a discount of 60 per cent.; if he used $50 worth, he got 50 per cent. off; if $35 worth, 40 per cent., and for $10 worth, 20 per cent. off. These discounts I contend were entirely wrong; and public opinion was aroused, and sounded such a protest against this discount system, which was to the benefit of the large consumer as against the interests of the small consumer, that this month the manager has announced that on and after December 1, instead of charging 25 cents per 1 000 watt-hours, the rate will be 12 cents to all consumers of electricity, less a discount of 2 cents, making a flat rate of 10 cents per 1 000 watt-hours. And I contend that the same principle should be endorsed by the New England Water Works Association and recommended to be applied to water. The present system encourages the fostering of trusts, because by combining interests they get their water much cheaper than they could individually, to the disadvantage of the small user.

I attended this meeting with the expectation of hearing the

report of the Committee on Meter Rates and to hear what members might say upon the subject. This is what I have to offer, and it is my intention to have adopted by our water board, if it is possible, the ideas which I have expressed.

MR. DESMOND FITZGERALD.* For one, Mr. President, I wish to say that I have been much delighted to hear such sentiments as Mr. McLean has expressed, and to hear them so well put.

MR. MORRIS R. SHERRERD.† May I ask Mr. McLean if he proposes to couple with his uniform rates for metered water a minimum rate for service?

MR. MCLEAN. Our rate for metered water is, as I stated, where the monthly consumption is 50 000 gallons or less, 12 cents per 1 000 gallons. Now you can see the injustice which results to the small consumer. The large consumer gets all his water at the 4-cent rate, and we are building reservoirs, you might say, for him, while the smaller consumers pay 12 cents per thousand gallons. For the first 50 000 gallons the charge is 12 cents, for the next 200 000 it is 8, and for over that, 4 cents.

MR. SHERRERD. Must the consumer pay a certain minimum amount in order to get the water at all?

MR. MCLEAN. Yes.

MR. SHERRERD. How much is that a year?

MR. MCLEAN. If he only uses 50 000 gallons a month or less, the rate is 12 cents.

MR. SHERRERD. What is the least possible charge that a family could get through on? Is it $2 or $3 a year, or something of that kind?

MR. MCLEAN. All faucet charges are at a stipulated rate, and families pay a stipulated price, $3.60 a family per year, *net*.

MR. SHERRERD. Without meters?

MR. MCLEAN. Without meters; the idea is to encourage the use of meters and make the price as nearly equal to all as possible, by having a standard rate for all water, whether a man uses one thousand gallons or a million gallons.

MR. HOLDEN. Does the city furnish the meter, or the consumer?

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* Consulting Engineer, Brookline, Mass.

† Engineer and Superintendent Water Department, Newark, N. J.

MR. MCLEAN. The city.

MR. SHERRERD. It seems to me that there are two elements which enter into the cost of water; one is the water itself, and the other is the cost of the plant to distribute the water. I have gone into the question pretty thoroughly, and although the speaker who preceded me may perhaps be right theoretically, yet it seems to me there must be a fixed amount paid by each consumer before he begins to pay for the water. On the Newark, N. J., plant that amount figures $4 on each tap. This represents the interest charge on the cost of the distribution system; that is, it costs the city $4 a tap before a single gallon of water is delivered to the consumers. If you have a 25-foot lot, and you take water for your house by meter, you may get through, at our rate, for from $8 to $10 per year. Your neighbor may have a 25-foot lot on which he has a factory, and he uses, we will say, $100 worth of water. Now it practically costs the city the same amount of interest on the plant to bring the water of the small consumer, who only pays $8 to the city, that it does to bring it to the large consumer, because the mains have got to be large enough for fire protection in any event, whether that consumer is there or not. And it seems to me that this situation ought to be taken into consideration when the question of fixing rates comes up.

Then to prevent meter consumers combining to get larger discount, it would seem to me that a water department, particularly a municipal department, could control this by making the sliding scale apply to each meter or to each building, and thus prevent any combination of interests, scattered all over the city, from getting the benefit of the large reduction in price. I know that with us it would be a pretty serious thing if we were to raise the rate to our large consumers. I agree that it is nice to talk about making the rate as low to the small consumers as to the large ones, but if we should not give a reasonable discount, so as to bring the price of the water down, our larger consumers would be able to get an adequate supply of water for their cooling purposes, and satisfactory for all but boiler use, by taking it from driven wells. If we should attempt to make a uniform rate, I know that we would lose a large portion of factory con-

sumption, and I think the same thing might be true in other localities.

MR. MCLEAN. I would say that for all services that we put in we charge the consumer as far as the curbing on the sidewalk. If a man owns four hundred tenements, he is charged $3.60 a year for every faucet, every tap in every tenement, while the readings of meters belonging to the large corporations are added together, thus bringing the price to the lowest rate.

MR. SHERRERD. Put him on a meter.

MR. MCLEAN. His tenements are distributed all over the city, and he pays $3.60 a year for each tenement; while the consolidated interests, which meter their water, as I have before cited, get the benefit of the low rate. All their meters are read as one meter. It is impossible to read every meter on its own basis, because that would put the rates up, unless the rates were changed. The only fair and just way, under municipal ownership of the plant, to all the citizens, who are equal owners in the plant, is to make a flat rate as low as possible; just as the United States government makes its rate on postage stamps, or its duties, or anything else, the same rate to each and every individual. Consequently, I contend that it is the duty of all municipalities to charge a flat rate of so much per 1 000 gallons.

MR. ROBERT J. THOMAS.* I think, Mr. President, that it is the duty of a municipality to furnish water to its citizens at the lowest possible rate, — to furnish a first-class quality of water and plenty of it, at the lowest possible rate. Now, it seems to me that if by reducing the price of water the municipality can increase the number of takers, and thereby increase the revenue, it will be able to furnish to all the citizens water at a lower price than would be possible otherwise. As Mr. Sherrerd has well said, a great many large water takers would put in pumps, drive wells, or take water from other sources, and thereby deprive the city of a large revenue, if they did not receive an inducement in the way of reduced rates for a large consumption.

The highest rate in Lowell is 14 cents per 100 cubic feet for the first 20 000 cubic feet in a quarter; for the second 20 000, the charge is 13 cents; for the third 20 000, 12 cents, and so on, the

* Superintendent of Water Works, Lowell, Mass.

lowest rate being 10 cents. But we do not give water takers the benefit of that sliding scale, except on a single meter. If they have two meters or more, they are charged separately for each meter.

One of the benefits to be derived from a sliding scale, and I presume it was one of the motives for establishing it, is that instead of having three or four services for one piece of property, thereby increasing the cost of maintenance to the water department, they get along with only one pipe and one meter, decreasing the number of services and the number of meters and consequently decreasing the cost of maintenance. I can't see the necessity, in Holyoke or in any other place, of taking all the meters of one concern, considering them as one account, and giving them the benefit of the sliding scale. That is, it seems to me unnecessary, and is not the practice throughout New England. It certainly is not the practice in Lowell, and I believe we follow the general practice pretty closely.

Another reason for the adoption of a sliding scale is that the more revenue you can get from your plant the easier it will be to reduce your rates to all water takers. Of course, the question has two sides to it, and it will bear discussion and looking into. I feel that it has not been discussed as much as it ought to be by the Association, and that it is very opportune to bring it up to-day. Mr. McLean has done good service in calling it to the attention of the Association, and it ought to be further discussed, for to my mind it is not by any means a settled proposition that it is the duty of a municipality to furnish all its citizens with water at the same price, regardless of quantity used.

Mr. Coggeshall. Do you have a minimum rate for meters, Mr. Thomas?

Mr. Thomas. We have a minimum rate of $7.

Mr. FitzGerald. It has often struck me, Mr. President, that this idea which Mr. McLean has advanced runs through all our systems of business. If I go to a railroad station and wish to go to Newton, and I can afford it, I buy a package of tickets, so that the cost of my trip is very much reduced; whereas a poor woman, who is only going out there once, perhaps, has to pay nearly twice as much for her trip as I do. It seems to me that

in the case of a public carrier that is all wrong. In this particular case it costs the railroad just as much to carry me as it does to carry her, and I think we should pay the same.

This is a subject which I have thought of a good deal — in fact I believe I am on a committee which has been appointed in an adjoining municipality to consider this very subject — and I believe, as my friend Mr. Thomas says, that it is a question which has two sides; and I think it will be an excellent thing for the Association to take it up and make a business of discussing it. I am sure that the varied experiences and opinions of our members would make the discussion exceedingly interesting.

MR. MCLEAN. While I have a good deal of respect for the views which other members have expressed, and I think there is a good deal of justice in their contention, I am still of the opinion that the only fair way is to have an equal rate for all. Where municipal ownership has been made a success, equal rates have been charged to all for the product of the municipality, whether gas or light or water or anything else. In New Zealand the railroads are under public ownership, and it doesn't make any odds whether a man ships 1 000 tons of freight or 100 pounds, his shipment goes at the same rate; and so, under municipal ownership, water should be supplied at the same rate to all citizens. It is not the same as with private ownership. A private company can do what it wants to, but under municipal ownership every individual is a part owner of the plant, and he should have equal rights. Realizing that, the Holyoke lighting department, which is the only municipal department of its kind in the state on a large scale, will supply the citizens at a uniform rate in the future; whereas previous to the adoption of the new system many were getting 60 per cent. off, while the small consumer was getting only 20 per cent. off. There is no justice in operating a municipal department for the benefit of the large consumer, as we are now operating the municipal water department, building reservoirs and borrowing and expending large sums of money in laying pipes to supply his needs, and giving him water at the very lowest rates possible, three times lower than others. I contend it is the duty of the municipality to supply all of its citizens with water at one price, and if the large consumers refuse

to take it, well and good. But I don't believe they will. I know of no large user of light or power from the electric department who has stopped taking it since the change of discounts, and so with the water; I believe with a flat even rate to all we will still be able to furnish water to all cheaper than they can procure it for themselves, and of a better quality.

MR. ROBERT SPURR WESTON.* I should like to ask Mr. McLean if the present minimum meter rate at Holyoke is less than the cost of furnishing water?

MR. MCLEAN. I cannot answer that correctly at present; we are now installing four large meters, — two Venturi and two Premier, — which will show our hourly and daily total consumption; then we can come very near to knowing exactly what we are doing.

MR. CALEB M. SAVILLE. May I ask Mr. McLean if he advocates a universal meter system?

MR. MCLEAN. I do; yes, sir.

MR. SAVILLE. On everything?

MR. MCLEAN. I do. I think it is only a question of time and enlightening the citizens as to the advisability of using meters. It is a hard task to do it, but the time is coming when they will see it. We all know from experience with faucets and fixed charges that the leakage is enormous. Sometimes a ¼-inch opening may run half the year without our knowing it, and leaks are occurring all the time. If all services were metered it would be better, and it would not take as much water to supply the municipality.

MR. MERRILL. I do not know whether Mr. McLean attended the meeting, or read the preliminary report of this committee which was presented in the spring, but if so he will recall, undoubtedly, that the statement was made at that time that the city of Somerville had looked at the matter in much the same light that he does, and so far as it was able had placed the metered water charges on a uniform basis, abandoning the sliding scale which had formerly existed, of 14 cents for the first 20 000 cubic feet used in a quarter, 13 cents for the second 20 000, and 12 cents for the next 960 000 and 8 cents for anything over a million, and

* Sanitary Expert, Boston, Mass.

substituting therefor the uniform rate of 12 cents for 100 cubic feet.

I will not say that that was made to apply to every consumer, because we have, I think, three out of our 11 000 rate-payers who use water in so large quantities that it was deemed inadvisable to increase their old minimum 8-cent rate to the otherwise uniform rate of 12 cents. Conditions must decide whether the uniform rate can be made to apply to all cases. One of the companies to which I have referred has a local water plant of its own now, and I think there is no doubt that if such an increase in its water charges as would result from advancing its minimum 8-cent rate to a uniform 12-cent rate had been made, we should have lost a considerable portion of its patronage. But with these exceptions we are on the uniform basis of 12 cents per 100 feet or 16 cents per 1 000 gallons; and I am inclined to agree with Mr. McLean that, where circumstances will permit, that is the proper way to charge for water.

MR. CHARLES W. SHERMAN.* One of the companies with which I am now connected has found itself in a situation very similar to that described by Mr. Merrill. In the city in which it operates is a very large plant belonging to one of the so-called trusts, which employs a large percentage of the men of the place. Formerly, with the water supply under a different management and partially under the control of the municipality, that concern was allowed to have water free. A new management having taken hold of the water plant, an attempt was made to put the rate up to that paid by other consumers; I do not pretend to say it is a flat rate, however theoretically proper such a rate would be, but to what any one else would pay for the same quantity of water. It was found to be absolutely impossible to do that, for if it were done the plant would be closed and the business moved out of town.

Now, in my opinion, the theoretically proper way to get over that circumstance would be by receiving from some source the same sum of money that another consumer would have paid for that quantity of water; and the balance in excess of what the plant could afford to pay in that location should be made up by

* Assistant Manager Water Companies, Boston, Mass.

general taxation on the municipality, and not by increasing the water rates to other consumers; that is, by making the whole municipality and not the water-takers stand the difference. That was a case where it would have been suicide for the water company to establish a rate such as would force the manufacturing plant out of town, since it would have practically killed the municipality; and the result was that a rate was made substantially covering the cost of the water, possibly a fraction of a cent less than the cost to the company — and of course the balance has to be obtained out of the other water consumers. It is not right, but I do not see how we can do any better.

MR. SHERRERD. May I go a step further, Mr. President, with what I said on the subject when I was speaking of the lots? I forgot to mention that there is another factor which should be taken into account, and that is the vacant lot in front of which a pipe is laid. That lot gets the benefit, as all the real estate in the city gets the benefit, from the large pipes for fire protection. But I know that in some cities — and one I know positively about; that is, Troy, N. Y. — they charge in the tax levy, and it goes in the tax bill on the real estate, $5 on a 25-foot lot for every lot in front of which the water pipes are laid. That is really equivalent to taking care of this item of $4, which I spoke of before; and perhaps it is, from a theoretical standpoint, a fairer way to distribute the cost of the distribution system upon the real estate. Of course this always raises an objection on the part of large owners of vacant land, but I know that in the development of such tracts of land these same owners are anxious to have the water department, or the water company, lay water pipes through the streets on which the lots abut, because the lots are thereby increased in value and brought into the market. And if that is true, if the pipes of the water department increase the value of the real estate, it seems to me that the real estate ought to pay a portion of the fixed charge, and that would leave the way open for the establishment of some uniform rate for the water.

MR. MCLEAN. If the Association is ready at this time, I would make a motion that it is the sense of this meeting that we adopt some kind of a system such as has been suggested.

THE PRESIDENT. I think, Mr. McLean, that, pending the report of the committee, it would hardly be advisable at this time to take any action. The committee has the matter under consideration and has merely reported progress, merely outlining some of the points that have come up in the minds of the committee as to the many difficulties there are in the way of fixing a uniform meter rate.

MR. MCLEAN. Each city, of course, has its own problems in that respect, but I think the nearer to a uniform system the Association could adopt, the better it would be. The way we in Holyoke get over the difficulty that my friend on the left [Mr. Sherrerd] suggests is by taxing the fire department so much for every hydrant that it has. It pays us, I believe, $8 a year for each hydrant. I suppose we all have our different ways of doing these things, but the more uniformity there could be about it, it seems to me, the better it would be.

WATER TANK AND TOWER FOR EAST PROVIDENCE, R. I.

BY F. M. BOWMAN, STRUCTURAL ENGINEER, RITER-CONLEY MFG. CO., PITTSBURG, PA.

[*Read November 9, 1904.*]

During the fall of this year the East Providence Water Company completed its new water tank and tower at East Providence, R. I., and as the structure is in several respects the largest of its type, a description of it in detail will, no doubt, be of interest.

The tower is 135 feet high from base of column to base of tank, and the tank is 50 feet diameter by 70 feet high, with a capacity of 1 000 000 gallons. The height from the base is therefore 205 feet for water pressure, and the total height to the top of the finial is 234 feet. The structure, a view of which is shown in Plate I, makes a water reservoir for fire protection for East Providence and Riverside, R. I., it being located on an elevated point about half way between the two places; the pumping station, however, is located some three miles from the site of the tower.

For ten years previous to the completion of this structure these cities were supplied with water directly from the pumps, there being no reservoir of any kind. The pressure now obtained is great, and the residents find it necessary to look carefully to their plumbing.

Referring to the details of design, it is to be noted that the tower has four center and eight outside columns, as shown in Plate III, Fig. 1. Most of the direct load is carried on the four center columns, each column carrying, approximately, 700 tons. The location is such that the foundations are carried to solid rock, making ideal construction. The foundations are of concrete, except that a granite cap stone in one piece is used under each of the twelve columns, — in the case of each center column this cap stone being 3 feet × 6 feet 6 inches × 6 feet 6 inches, and weighing 11 tons. The lower section of this column weighs 12

tons, exclusive of cast-iron base (Fig. 1) and consists of two web plates 15 × ⅜ inches, four flange angles 6 × 6 × 1 1/16 inches and four cover plates 24 × 1 1/16 inches.

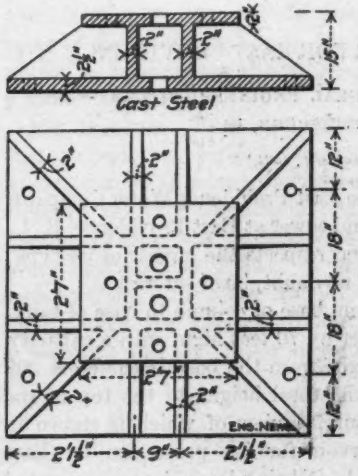


FIG. 1.

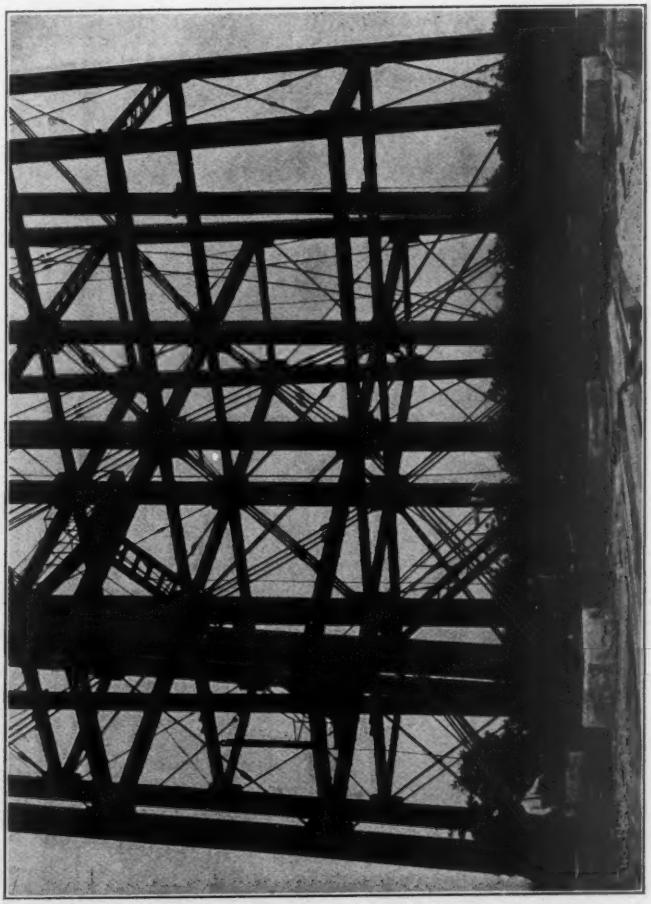
The wind pressure was figured at 50 pounds per square foot of exposed surface for the tower, and in the case of the tank the pressure was assumed as two thirds of this load on the diametrical area instead of the usual one half. The horizontal wind strains from the tank are carried almost entirely by the eight outside columns, which act as the top and bottom chords of a cantilever girder with panel points at every third horizontal strut, the cantilever being fixed to the ground by the anchor bolts.

The floor beams for the platform are 12-inch I-beams, carried on box girders spaced about 9 feet on centers, these in turn being carried on pin connected girders; the load from the box girders is transmitted by direct bearing to the center post of the pin connected girders. The platform itself is made of concrete 16 inches thick, thus making the bottom of the tank frost proof and protecting the lower surface of same from rust. The concrete is extended to the hand railing along the edge of the platform and forms a foot-walk around the tank.

The bottom of the tank is of ½-inch steel plates; the sides vary in thickness from 1 1/16 inch for bottom ring to ⅜ inch for top ring. The horizontal seams are lap joints with two rows of rivets ⅞ inch in diameter for the lower rings; the upper seams have one row only with ¾-inch rivets. The vertical seams are butt joints for the lower eight courses and lap joints for the upper six. The butt joints have two splice plates, the inner one about twice as

PLATE I.

EAST PROVIDENCE WATER TANK AND TOWER.



FOOTINGS OF COLUMNS.

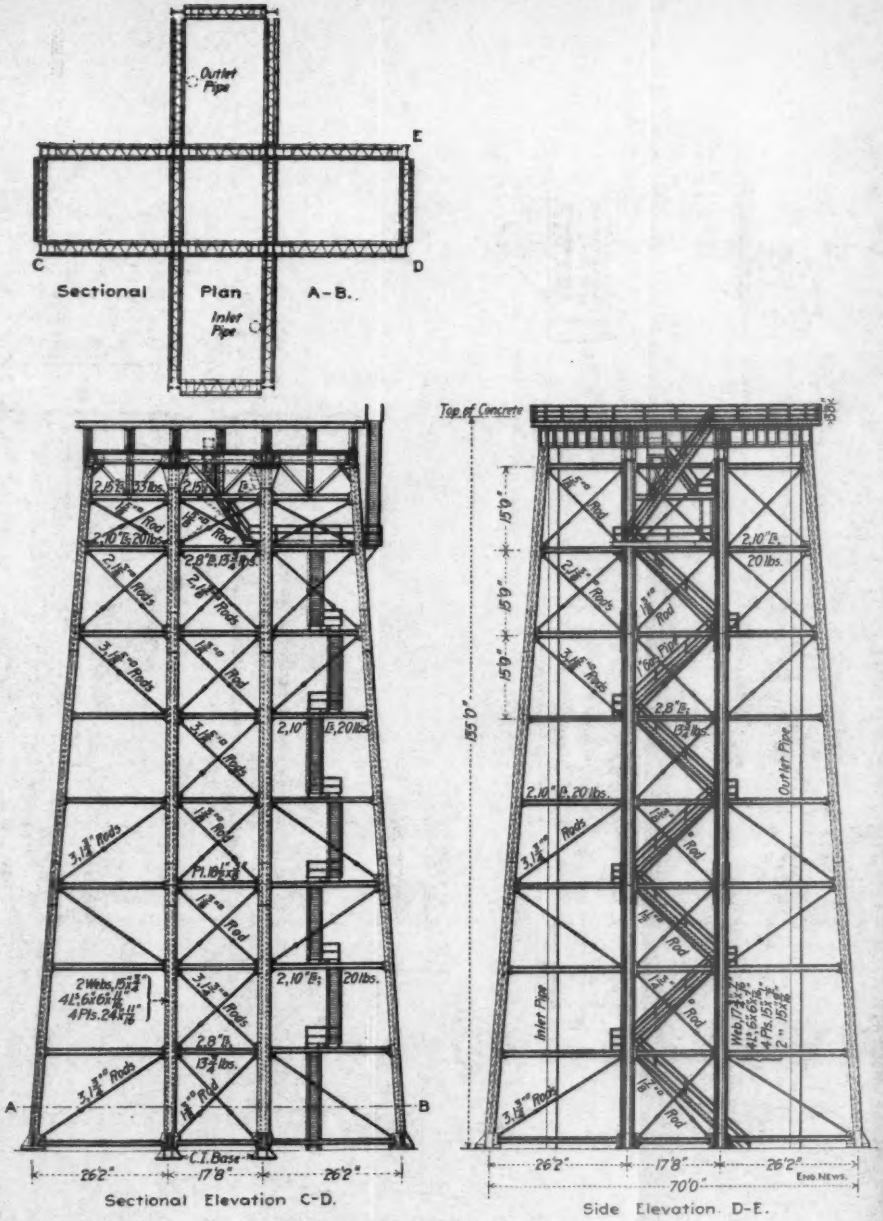
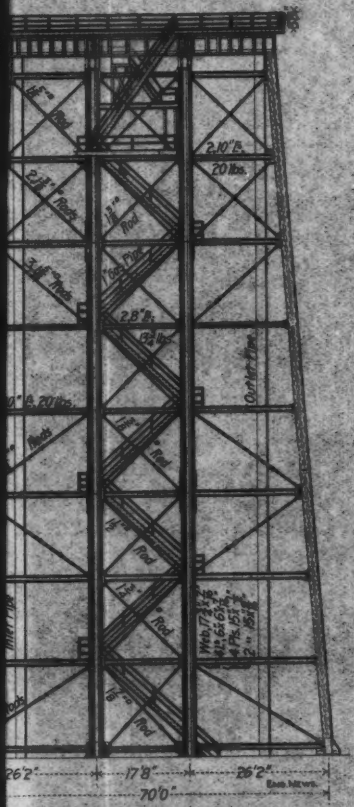
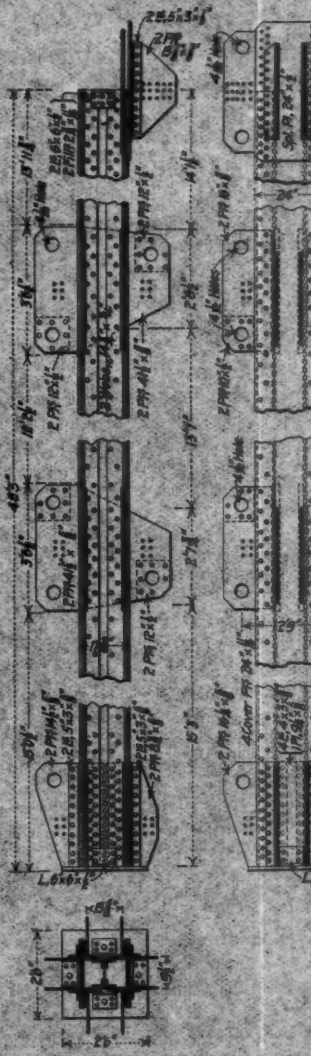

Outlet Pipe
E
C
D
Sectional Plan A-B.
Inlet Pipe
A
B
C.I. Base
26'2"
17'8"
26'2"
Sectional Elevation C-D.
Top of Concrete
155'0"
15'9"
15'9"
15'9"
Outlet Pipe.
Inlet Pipe
26'2"
17'8"
26'2"
70'0"
Side Elevation D-E.

FIG. 1.


26'2"
17'8"
26'2"
70'0"
Side Elevation D-E.



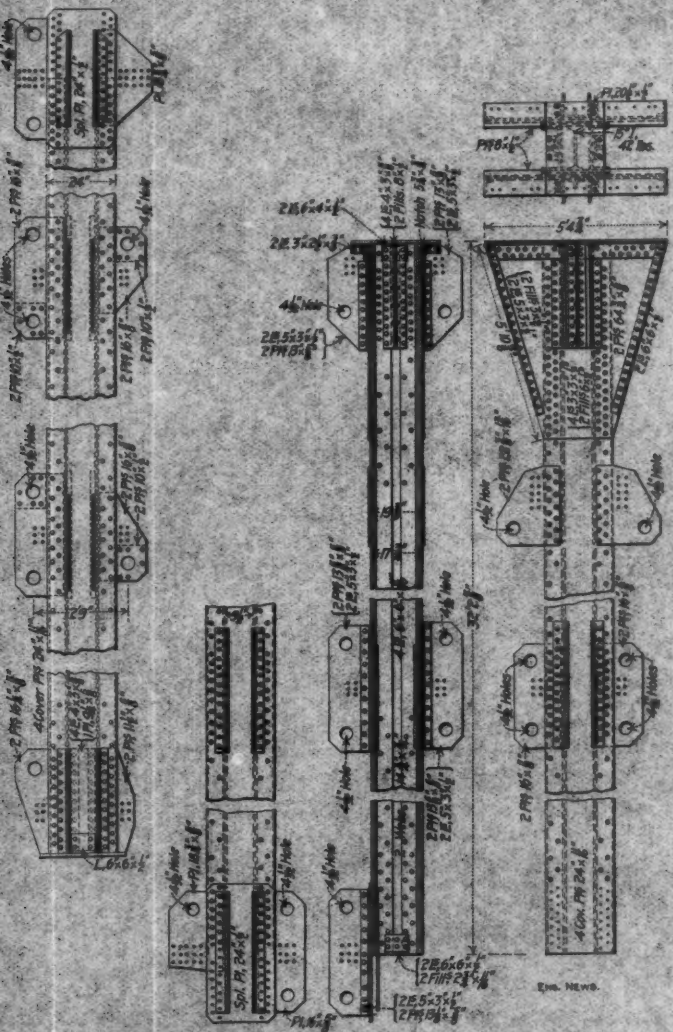


FIG. 2. DETAILS OF COLUMNS.

1.78"
1.89"
1.27"
.75"

wide as the outer to increase the percentage efficiency of the joint. The diameter of rivets varies from 1 inch for the lower ring to $\frac{3}{4}$ inch at the top. The tank is anchored to the tower with eight bolts 2 inches in diameter connected to the lower course of side plates and to the web plates of supporting girders.

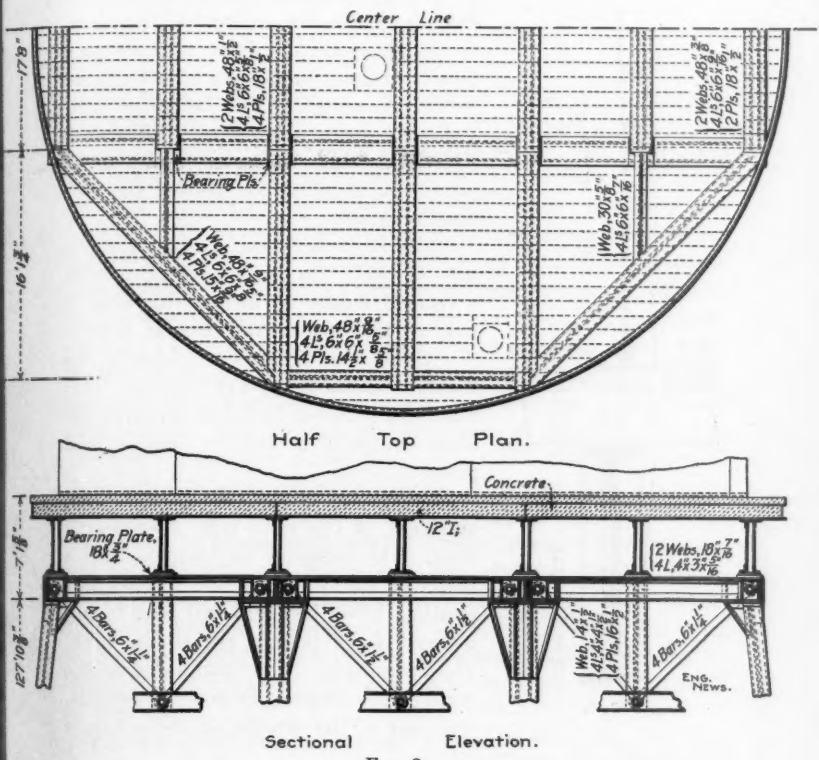


FIG. 2.

A balcony is provided around the side at the top of the tank. An opening 30 inches deep is allowed between the top of the shell and the roof line for ventilation, the opening being covered with heavy wire screen. The roof consists of $\frac{1}{8}$-inch plates riveted

together and supported on steel trusses, the finial being a 24-inch copper ball.

The inlet and outlet pipes are 14¼ inches inside diameter, of steel pipe supported on suitable foundation in a pit where the gate valve is located; they are attached to the tower by steel ties at the cross struts, and a slip joint is provided at the top section for expansion. Steel flanges are used for pipe connections and the pipe is covered with three inches of asbestos, this being in turn protected by a sheet metal cylinder ⅛ inch thick, made in halves, with flanges projecting outward for bolting the sections together.

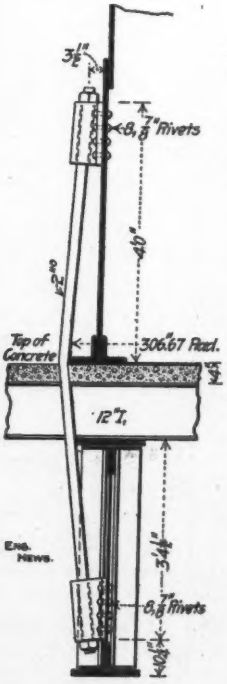


FIG. 3.

Stairs 30 inches wide are furnished to base of tank; the tank is provided with a vertical ladder 15 inches wide with a balcony half way up the tank as a rest. A separate stair is also provided to the manhole in the bottom of the tank; this manhole, 16 inches in diameter, being for access to inside of tank for cleaning and painting.

The material of the tower is medium, and that of the tank soft, open-hearth steel. The structure is designed with a factor of safety of four, the tension unit strain in tower being 14 000 pounds and in tank 11 000 pounds per square inch. The pressure of the column bases on the granite caps does not exceed 400 pounds, and that of the granite on the concrete 250 pounds per square inch.

The erection had to be carried on carefully on account of the great height and the prevalent high winds, and the work was slow and expensive for these reasons and because it was impossible to carry on the raising of material and the driving of rivets at the same time. The raising of material had to be abandoned

when the riveting was in progress, as otherwise the riveters were liable to accident and injury. The work was carried on under the supervision of the engineers of the Water Company, Messrs. Bushnell and Wood, the Riter-Conley Manufacturing Company, Pittsburg, Pa., being the contractors.

DISCUSSION.

MR. ARTHUR B. LISLE.* The situation is just as Mr. Bowman has stated in his paper, and the only thing which occurs to me which perhaps would be of an additional interest to the members of the Association is a statement of some of the reasons for putting up such a standpipe, and the advantage that we hoped to gain thereby. We have no other reservoir, and being practically forced by the demands of the insurance people to have some reserve in case of fire, — for although we have duplicate pumping apparatus, in case of accident during a fire that would not be of enough assistance, — we were practically forced to put in a standpipe. Our reason for putting in one of such size and type was to give us a pressure which would be satisfactory to all interests. This standpipe will give us a pressure of 150 pounds at tide water, and as much of our territory is near tide water, and our largest business, especially our manufacturing business, is all near tide water, we will get 125 to 140 pounds pressure for almost all of our large customers. That pressure will be of more or less assistance to us, not only from the fire protection standpoint but from the commercial standpoint, by enabling us to get business from manufacturers; because this pressure will obviate the necessity of using feed pumps, injectors, etc., and it will allow the feeding of boilers direct from the system. It has already worked to our advantage in that way.

The standpipe is large enough for the territory we have to furnish and to take care of any ordinary fire demands. We could get along with the standpipe for possibly a day and a half in case anything should happen to our pumping apparatus, and although it is not a large system and the amount of water is not very great, the standpipe puts us in a position where we are so much better

* Treasurer, East Providence Water Co.

off than we were before that we feel quite pleased. We had some trepidation because we feared that the high pressure might cause a lot of trouble on our mains, as previously we had never had much over 80 pounds. But during the last five years, anticipating this change somewhat, we have laid only the heaviest pipe and have tried to make the joints such as to avoid trouble of this kind. The standpipe has been in service now for nearly a month, and we have had no breaks, other than the blowing out of a couple of dead ends where there was probably some water-hammer.

PRESIDENT E. C. BROOKS. Would you care to tell us approximately what the structure cost, Mr. Lisle?

MR. LISLE. I do not think it would do any harm to say that it cost a little less than $100 000.

MR. FRANCIS W. DEAN.* Mr. President, I have from time to time taken some interest in the designs of towers for this purpose. I note that there is an angle-iron at the bottom on the inside as well as on the outside, as is usually the custom. The method of placing the angle-iron on the outside only is very bad construction, and I think it is in a measure responsible for some of the failures which have occurred. The angle-iron would necessarily be quite large, — I suppose it is frequently 6 × 6 inches, and as the rivets therein are near the outer edge, in order to be able to calk the joint properly, you will see that under this angle-iron there is quite a width of plate, where there is an upward pressure. The weight of the tower itself, that is, of the outside shell, resists it, but nevertheless there is an upward effort due to the water pressure, which amounts to a great deal, and which tends to bend the bottom plate. Such bending undoubtedly takes place at times, especially when there is a heavy wind; and it acts on the plate just as a lap joint on the longitudinal seam of a boiler acts. A lap joint on the longitudinal seam of a boiler is responsible for nearly all boiler explosions, because the lap joint, being stiff, and the shell being out of round due to the lap, it bends at the edge of the lap, with changes in pressure, and finally starts a crack. A great many boilers have cracked enough to let a little steam through and thus have given warning. Similarly the bottom plate of a standpipe after bending under the angle can very easily

* Mechanical Engineer, Boston, Mass.

rupture, and in many cases the only thing which holds the standpipe down is the weight of the water on the bottom.

If the angle-iron is on the inside, so that the calking is on the inside and no water pressure can get under the angle-iron, this source of rupture cannot exist.

The drawing also shows that the tank is held to the platform by means of bolts on the outside, going up some distance on the outside, and taking hold of the shell. Now, as matter of fact, they should go up a long distance, and no dependence whatever ought to be placed on the weight of the water in holding down the bottom. The resistance to the tower's overturning should come from these bolts and they should go up sufficiently far to make the outside act as a vertical girder, so as to distribute the pull which may come on the bolt.

Moreover, I think that such tanks should be so strongly braced on the inside that they become very stiff. I think one great trouble with standpipes has been that they have been too limber; the wind has too great an opportunity to bend them in and work them back and forth. Of course, where a tower is roofed as this is, and the cover is fastened, it receives therefrom some degree of rigidity at the top; but I think, as I have just said, that towers of this kind should be made thoroughly rigid throughout. In fact, it has sometimes seemed to me as if there ought to be some vertical and circular girders on the outside or inside, to make the structure absolutely rigid.

MR. MORRIS R. SHERRERD.* Mr. President, I should like to ask a question, for my own information more than for anything else. I have understood that some failures of standpipes have occurred by reason of the mass of ice that forms in the upper portion acting somewhat as a piston. As the water is drawn down from under three or four or perhaps five feet of ice in the top of the standpipe, it leaves an air space, and then the action of the sun on the sides of the standpipe loosens that plunger and allows it to come down on the water, thus creating a hammer that would tend to explode the pipe. I think perhaps you New England people have had more experience in standpipe construction than some of us around New York have had, and I would like to ask

* Engineer and Superintendent, Water Department, Newark, N. J.

whether it would seem advisable to have some construction in the upper portion of the pipe which will hold this mass of ice and keep it from dropping? I have thought that perhaps it might be well to have some cross-arms which would reach down 15 or 20 feet, perhaps 30 feet, from the top of the standpipe, to prevent this mass of ice from dropping.

THE PRESIDENT. Have you any information to give on that subject, Mr. Dean?

MR. DEAN. No, I have not. I have read more or less that has been written about the effect of ice, and have heard the subject discussed somewhat, but it never seemed to me at all a satisfactory explanation for the failure of a standpipe. We have all seen, of course, statements that the expansion of the ice would cause a rupture, but it seems to me that the expansion takes place so soon after the ice begins to form that the effect would be to crush the ice and not to rupture the shell.

MR. LISLE. I will state, Mr. President, that the conditions with us are very peculiar, and the possible trouble from ice is one of the things we are worrying about as much as anything else. We pump from a rapidly flowing stream. Last winter we took a lot of temperature observations during the cold weather, — and, as you know, it was very cold last winter, — and for days at a time we got a temperature in the river of 27 or 28 degrees. Now, when we pump that water into the standpipe, although it has to go through the ground for three miles, we are a little bit afraid it is going to freeze as soon as it gets there. I should like to know if any of the members have had any experience as to what is the warming effect on water of going through the ground for three miles, — whether it would be enough to raise the temperature sufficiently to overcome the danger of freezing.

THE PRESIDENT. I should like to know if any member has had any experience in regard to the temperatures of water which will be of any guidance to Mr. Lisle. I have never been able to get water even down to freezing in a hole cut through the ice in a pond, and it does seem as though Mr. Lisle's extraordinarily low temperatures were something new and novel. I have certainly never heard of anything of the kind. Do you know, Mr. Lisle, may I ask, whether the thermometer you used was standard?

MR. LISLE. I do not know of my own knowledge, but some tests were made last winter in anticipation of trouble from freezing, and that report was made by Mr. Bushnell. I do not know the details but will be very glad to procure them and submit them to the Association at some future time.*

MR. DESMOND FITZGERALD.† A number of years ago I was making some experiments at Chestnut Hill Reservoir, and I had a 16-inch pipe in the yard filled with water, in which was floating a copper ball which nearly fitted the pipe, so that there was only about half an inch of space all around. The copper ball was weighted so that only a very little of the upper part of it was above the water, so that the angle formed with the surface of the water was very acute. During the night the weather suddenly became very cold and the water froze about half an inch in depth around the copper ball and burst a hole through it. The thrust took place on an angle of about 10 or 15 degrees. This result will give an idea of the power of ice in expanding, and developed the fact that instead of rising or of crushing the ice that small depth of ice had crushed a hole through the heavy ball. You can imagine the power which was exerted.

While I am on my feet, I will say a single word in the cause of an artistic treatment of standpipes and towers, and all other works connected with municipal water supply. I think members of our profession, engineers and water-works superintendents, are too apt to overlook that side of the matter. A very little additional care in regard to the proportions of these water towers, and to building them so that they will present an artistic effect, will make all the difference in the world. I am not speaking of the East Providence tower particularly and wish to make my remarks general, but I think it is a good plan for all of us who design such structures to keep in mind, first, the correct proportioning of the

* Since the above statement was made, I have investigated the tests made as to the temperature of running water and find that although the thermometer was standard and probably approximately correct, the tests were not made in a strictly scientific manner, *i. e.*, the thermometer was immersed in the river but was not read under water, so that although it was read as soon as possible after being removed from the water, the air temperature being about zero, the thermometer probably dropped two or three degrees between the time of being removed from the water and being read.

† Consulting Engineer, Brookline, Mass.

parts, and secondly, an artistic treatment of the design so as to make it attractive.

THE PRESIDENT. Wouldn't you apprehend, Mr. FitzGerald, that such a condition of things as that spoken of by Mr. Lisle would be very apt to show itself in the formation of anchor-ice?

MR. FITZGERALD. I don't know that I can answer your question, Mr. President, but I will say this, that I have made a great many observations on anchor-ice, particularly with the thermometer. In regard to the temperature of water just under the ice I have found that it is at the freezing point, or even at times slightly below it, but that temperature extends to a very slight depth. It is governed by the temperature of the air above the ice. Below that it is influenced by the temperature of the water, but directly under the ice you will get the temperature of freezing. The effect of freezing can be studied by placing some water in a pan and putting a thermometer in the water so it is entirely immersed horizontally. If it is a very accurate thermometer with graduations so wide that one can read to a tenth of a degree, it will be found that as the water gets down to the freezing point it will suddenly go below the freezing point about one degree before the ice begins to form, and the instant the ice begins to form as shown by the presence of little crystals of ice, the thermometer goes up again to 33 degrees. The heat is liberated by the action of freezing.

In regard to anchor-ice, I have always found that anchor-ice will form only when the whole mass of water in the pond is cooled down to 32 degrees and there is a wind; but if it is quiet, and the crystals begin to form at the surface, we do not have any anchor-ice.

MR. DEAN. I had an interesting experience some years ago, Mr. President, in regard to the temperature of water, and your asking if the water ever got to the freezing point reminds me of it. I was testing an engine at the Atlantic Mills in Lawrence. The water came from the Essex canal to the condenser, and as I wanted to know the temperature of the condensing water I had a hole drilled in the pipe and a tube inserted, and in that tube I put cylinder oil and placed a bare stem thermometer. After a while I saw that the thermometer registered just exactly 32

degrees. I supposed that the thermometer was not right, and I went and got another one made by either Green or Queen, I have forgotten which, — the first was a Huddleston thermometer, — and that also registered 32 degrees after a while. Then I put in still a third, and that registered 32 degrees. It was a great surprise to me to find that water coming from the canal would stand at 32 degrees, but after three thermometers, made by different makers, showed it, I thought it must be so.

MR. R. S. WESTON.* I have observed the temperature of water in natural rivers as low as 32.3 degrees, with floating ice in the stream. Another point I may mention, that it is possible to cool water down to between 30 and 31 degrees Fahrenheit, provided the water is kept perfectly quiet, but the slightest movement will cause the ice crystals to form and freezing will take place. I have cooled water down in a special apparatus and then slapped the surface of the water and seen it freeze in that way.

THE PRESIDENT. My only reason for asking about Mr. Lisle's observations was that I have always understood that water could be cooled below freezing provided it was kept perfectly quiet, but that if there was any motion to the water ice needles would form immediately.

MR. M. F. COLLINS.† I would say that at Lawrence we take the temperature of the water every day in connection with our filter, and 32 degrees is the lowest we ever get through the winter. After the water gets down to that temperature it stays at about the same for a month or two, but we never get it any lower.

THE PRESIDENT. At what depth do you take the temperatures?

MR. COLLINS. Probably two or three inches below the surface of the water. In passing to the pumping station the temperature of the water generally goes up two or three degrees. The water at the faucets has an average temperature of 43, 44 or 45 degrees throughout the winter.

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* Sanitary Expert, Boston, Mass.

† Superintendent of Water Works, Lawrence, Mass.

REPAIRS TO THE LINING OF A SMALL RESERVOIR ON POWDER HORN HILL, CHELSEA, MASS.

BY CALEB MILLS SAVILLE, DIVISION ENGINEER, METROPOLITAN WATER WORKS, BOSTON, MASS.

[*Read November 9, 1904.*]

What I have to present to you to-day should hardly be dignified by the name of a paper; it is rather a collection of notes on a small piece of work recently carried out on the Metropolitan Water Works.

Records of small undertakings are frequently of considerable value because, while they deal most often with matters in the line of maintenance, very little information can ordinarily be found concerning methods and cost of such work, and the data from larger works of similar character are usually not applicable. On this account the following description of some work in Chelsea is presented, not because of its difficulty, but because it is in line with work that any water-works man may expect to encounter, and the data given may be useful for purposes of comparison.

In connection with the high-service supply of Chelsea, Mass., is a small reservoir on Powder Horn Hill, holding about 1 000 000 gallons of water which is supplied from the high-service system of the Metropolitan Water Works.

The shape of the reservior is shown by the plan, Fig. 1. The top is 178 feet long, over all, and 98 feet wide; the bottom is 148 feet long and 68 feet wide. The depth is 15 feet, and the slope of the sides about 1 to 1. It is built partly in excavation and partly in fill, the material being unstratified glacial drift containing such a proportion of clay that it was excellent for building a reservoir bank.

The original work was done by Trumbull and Cheney in 1887 for the city of Chelsea. On first filling the reservoir with water the leakage was very considerable, and the work was found especially defective at the junction of the stone and brick paving.

After considerable discussion concerning methods of putting the reservoir in proper condition, a coating of cement mortar

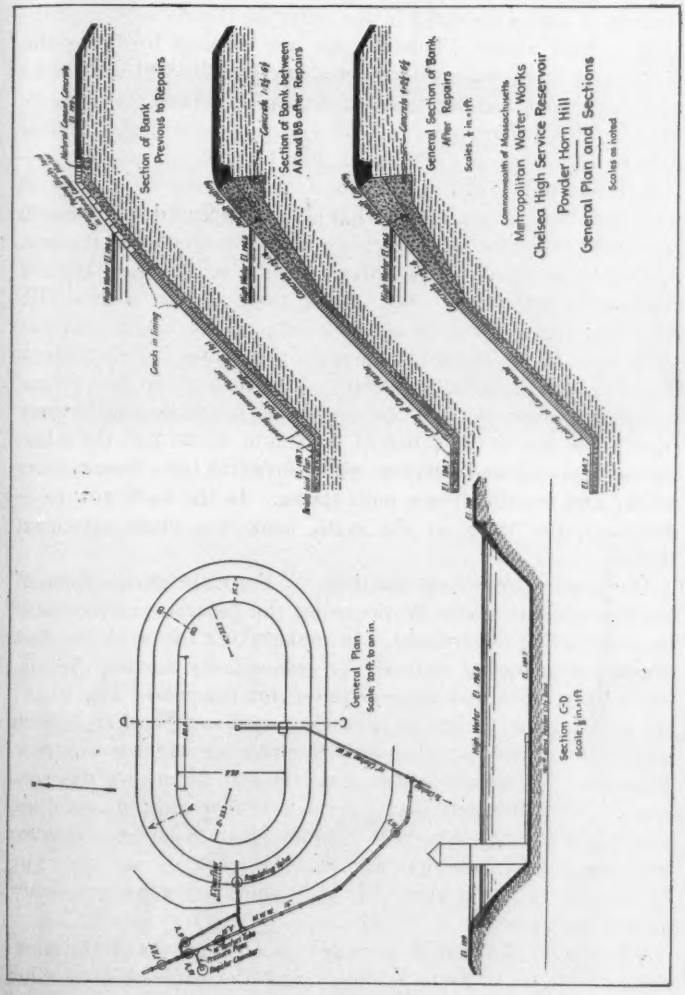

Section of Bank Previous to Repairs
Section of Bank between AA and BB after Repairs
General Section of Bank After Repairs
Scales, 1 in.=1ft.
Commonwealth of Massachusetts
Metropolitan Water Works
Chelsea High Service Reservoir
Powder Horn Hill
General Plan and Sections
Scales as noted
General Plan
Scale, 50 ft. to an in.
Section C-D
Scale, 1 in.=1ft
High Water El. 102.5

FIG. 1.

was finally applied to the whole of the inside slopes and bottom by a local mason.

No further trouble of serious nature developed until 1899, when horizontal cracks appeared in the lining on the slopes, due probably to frost action. This damage was repaired by filling the cracks and open places with cement mortar. In 1901 the cracks again appeared and were similarly stopped. When these cracks appeared for a third time, in 1903–4, it was realized that radical repairs were necessary. (Plate I, Fig. 1.)

In connection with these cracks it may perhaps be worthy of note that the greatest damage has always appeared on the south bank, and the cracks extended only partially around on the east and west ends, leaving the lining on the north bank intact and showing no defects. It may also be noted that at Forbes Hill reservoir, Quincy, the granolithic walk on the south side has twice been badly cracked, while that portion on the north bank has remained in good condition. The reason for this is not perfectly explainable, but the suggestion is offered that it may possibly be due to the action of the sun in winter and the intermittent thawing and freezing; while the north bank freezes more solidly and remains frozen until spring. In the work now to be described, the lining on the south bank was made somewhat thicker.

The work of repairing was done by the maintenance force of the Metropolitan Water Works under the general supervision of the engineering department. In undertaking the work the first consideration was of methods for economically moving the materials excavated and those required for concrete. The top of the bank was too narrow to allow the use of carts, and an 18-inch gage railroad was finally decided upon as most convenient. For removing the excavated material and depositing the concrete, a 65-foot boom derrick with a 70-foot mast was set up, together with a 15 horse-power double drum hoisting engine for working it. This derrick was held in place by six wire guy ropes; its reach was such that only one moving was necessary after it was placed.

The engine and derrick were set up on the floor of the reservoir, as shown in Plate I, Fig. 2, and the work of excavation

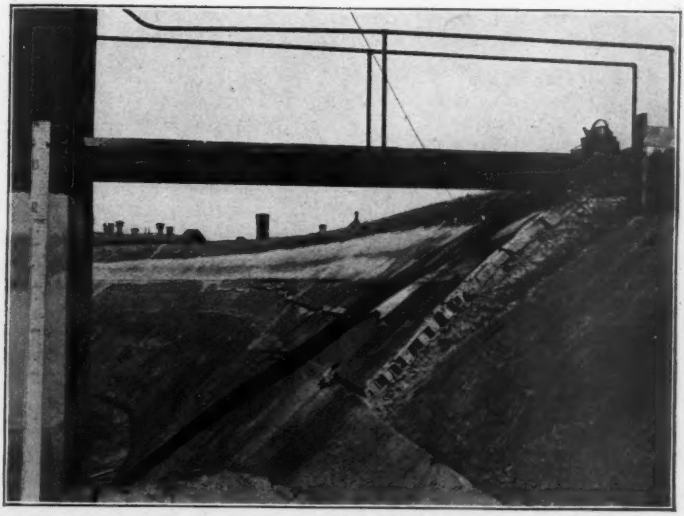


FIG. 1. CRACKS IN OLD LINING.

FIG. 2. PLANT EMPLOYED IN REPAIRING RESERVOIR LINING.

was begun at about the middle of the southerly side. In order to facilitate the work, a platform supported on "A" frames was set up. These forms were spaced about fifteen feet apart and rested on the bottom and slope of the reservoir, being held in place by bolts driven into the floor.

The paving blocks on the top of the slope were removed and piled up to be taken away; the old lining and the material excavated from the bank was shoveled into the scale pan of the derrick, hoisted to the cars on the top of the bank, and then run by gravity to a dump a short distance down the hillside. Here the cars were run out on a rough trestle, the load dumped, and the empty cars returned to the work by a rope carrried though pulleys to the winch head on the hoisting drum of the engine.

Two small portable storehouses were set up, — one 8 x 10 x 7 feet, the other 11 x 16 x 7 feet, — for the storage of some of the materials, but the bulky portions, such as cement, sand, and stone, were delivered as necessary, a few days' supply only being kept on hand. A branch from the railroad was so arranged that it passed the storehouses and stone piles, while the sand was piled close to the concrete mixing board. The intention on the work was to do nothing by hand that could possibly be done by steam, except that all of the concrete was mixed by hand. As great a proportion of water was used as could be done without causing the material to slide when rammed in place.

The lower layer of concrete was of the proportion by volume of 1 cement, 2½ sand, and 6½ crushed stone (sizes from ¾ to 1½ inches). This was rather a lean mixture, and as it could not be rammed enough to flush all over, the surface was finished where necessary by a thick mortar made in the proportion of 1 cement to 6 sand, and applied with heavy brushes. Before placing any of the concrete, the bank back of the old concrete left in place was thoroughly rammed with iron railroad tampers, and the edge of the old concrete was scrubbed with water and a stiff brush and then coated with 1 to 4 grout, which was allowed to fill in the angle between the concrete and the slope. Just before placing the concrete the earth bank was well wet in order that moisture might not be drawn from the concrete while it was soft.

In order to make the new lining as water-proof as possible,

a layer of asphalt was placed on top of the lower layer of concrete and brought up on the exposed edge of the old layer at the bottom of the new work (Plate II, Fig. 1). This, it was expected, would make an elastic and water-tight joint between the new and the old work.

Venezuela asphalt, "Crystal Brand," was used, being poured upon the top of the concrete layer and allowed to run down the slope, care being taken that the concrete was entirely and perfectly covered. After the first layer of asphalt was cool, a second layer was similarly applied, and the resulting sheet was about ¼ inch thick. Any inclination to crawl down the slope when exposed to the sun was readily stopped by throwing on a pailfull of cold water. A most particular part of this work was to get the asphalt as hot and liquid as possible and yet not burn it.

All of the concrete was protected from the sun and kept damp by being covered with strips of burlap, which were moistened by sprinkling.

The upper layer of concrete was composed of a much richer mixture of concrete than that used in the bottom layer, the proportions by volume being 1 cement, 1½ sand, 1½ stone dust, and 4 broken stone (of the sizes mentioned above).

On account of the steep slope it was possible to do only a little ramming, and the material was laid as wet as possible. To make this layer more impervious and also to obtain a smooth surface, the concrete was left about an inch below and a finish coat applied by expert granolithic finishers. This coating was applied as soon as it was possible to do so after the main layer was in place, but on account of the steepness and the liability of the wet concrete to flow, care had to be taken not to begin work too soon. This was one of the most important parts of the work, on the one hand to apply the finish as soon as possible and make a perfect bond by working it into the moist concrete, and on the other hand, not to work on the layer soon enough to cause it to run, when it would perhaps have to be later taken out and replaced. (Plate II, Fig. 2, and Plate III, Fig. 1.)

The top finishing coat was made in the proportion of 1 part cement, 1⅔ parts sand, and 3½ parts stone dust. In order to help in bonding, the last ramming on the concrete was done with

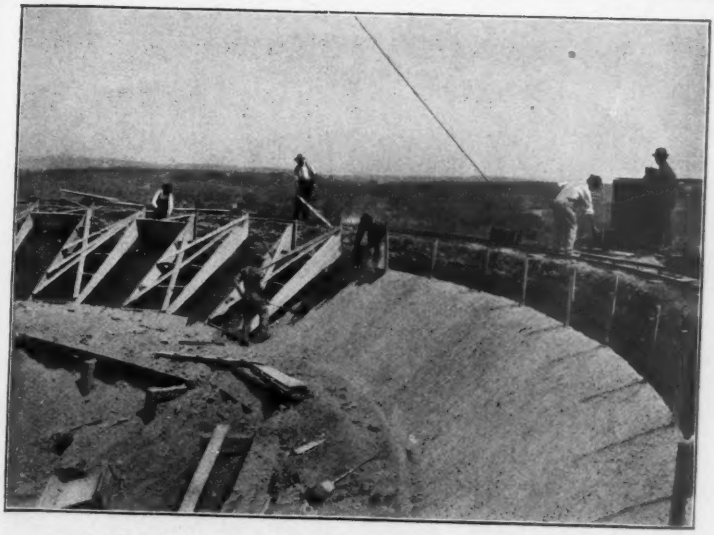


FIG. 1. COATING LOWER LAYER OF CONCRETE WITH ASPHALT.

FIG. 2. LAYING UPPER LAYER OF CONCRETE.

FIG. 1. LAYING AND SURFACING UPPER LAYER OF CONCRETE.

FIG. 2. RESERVOIR LINING COMPLETED.

rammers studded with pieces of iron about one inch long and one-half inch deep. The finishing was done in three operations; first, the material was spread on the concrete and thoroughly worked into it by the finishers, using rough wooden floats; after this it was gone over and partially smoothed down with a thin steel float; and finally it was worked to give the finished appearance and an impervious surface.

The under layer of concrete was placed in a continuous sheet; the upper layer was put down in alternate strips, 10 feet long (the whole length of the layer) and 5 feet wide. These blocks were built up in forms, as shown in Plate II, Fig. 1, which were not removed until the concrete had set. Finally, the back or edge of the block toward the bank was well wet and thoroughly plastered, to prevent as far as possible the infiltration of any water which might freeze and thus cause damage to the concrete. The plaster was proportioned 1 part cement to 4 parts sand. When the forms were wholly removed, the space between the concrete and the bank was refilled to within about six inches of the top, with the clayey material previously excavated and this space was filled and graded to the top of the bank with loam.

On work of this kind it appears that one of the principal items of cost is in the plant, its installation and removal. While this might probably be expected, this item is, nevertheless, a larger proportion of the cost than one who was not familiar with such work might look for.

The cost of labor and materials can be closely estimated, but the cost of plant can only be judged accurately by those familiar with its use.

The following detailed statement of the cost of this work is given, not as record-breaking, but as the actual expense under ordinary conditions.

Two holidays intervened, and the men were transported to and from work. While it may be said that these items would not wholly appear in contract work, it may also be noted that the men employed were of a higher order of intelligence than ordinary labor, and that the increased cost from these items was perhaps balanced by more efficient work at less cost for supervision.

TABLE No. 1.—Cost of Repairs

Class	Rate	Excavation		Lower Concrete		Upper Concrete		Back Plaster	
		Days	Cost	Days	Cost	Days	Cost	Days	Cost
LABOR									
Foreman	$4 00	9⅛	$38 22	3½	$15 11	6¼	$27 11		
Sub-foreman	3 00								
Engineer	3 00	12⅜	37 00	2⅜	7 00	1⅜	5 67		
Carpenter	2 67	2	5 33	7	18 67	18½	49 48		
Plasterer	5 40							3⅜	$21 00
Plasterer	6 00							⅞	5 33
Plasterer	4 50							5½	25 00
Asphalt man	2 00								
Watchman	2 00								
Laborers	2 25	9⅜	21 75	2⅜	6 00	1⅞	4 00	9⅜	21 00
Laborers	2 00	110⅜	220 44	89	178 00	119⅜	239 11	⅜	67
Laborers	1 75	46⅝	81 48	4	7 00				
D. Team	5 00								
S. Team	2 00								
S. Team	3 50								
Teaming									
Car fares									
Sum			$404 22		$231 78		$325 37		$73 00
PLANT	Rate								
Asphalt kettle	$1 50								
Derrick & engine	3 75	12⅜	$46 25	2⅜	$7 75	1⅜	$6 33		
Rails and cars	0 40	11⅛	4 49	2⅜	89	8⅜	3 33		
Sum			$50 74		$8 64		$9 66		
MATERIALS	Rate	Q'nt'y		Q'nt'y		Q'nt'y		Q'nt'y	
Cement, bbl.	$1 35			106⅜	$143 61	176¼	$238 27	6	$8 10
Sand, cu. yd.	1 10			37 44	41 18	30 22	33 24	3 30	3 63
Stone dust, tons	1 50					41 61	62 42		
Br'k'n st'ne, ton	1 35			117 88	159 14	122 76	165 73		
Loam, cu. yd.	1 25								
Stove coal, tons	6 50	3 05	$19 83						
Egg coal, tons	6 25	95	6 00	40	2 50	20	1 25		
Lumber, M ft.	21 00			1 30	27 30	4 00	84 00		
Asphalt, tons	30 00								
Kerosene, gal.	0 11								
Oil, gal.	0 25								
Burlap, yds.	0 04½					300	13 50		
Spikes, lbs.	0 05								
Nails, lbs.						170	4 50		
Asphalt mops									
Sum			$25 83		$373 73		$602 91		$11 73
Total			$480 79		$614 15		$937 94		$84 73
Estimated proportion, cost of plant installation & holidays		70 3%	$650 84	12%	$111 10	15 4%	$142 57		
Total cost			$1 131 63		$725 25		$1 080 51		$84 73
Total quantities			300 cu. yd.		95 5 cu. yd.		129 2 cu. yd.		262 sq. yd.
Cost per unit			$3 77		$7 59		$8 37		$0 32

TO LINING OF CHELSEA RESERVOIR.

SURFACING		ASPHALT		BACK FILL		INSTALLING PLANT		TRANSPORTATION AND HOLIDAYS		SUMMARY LABOR AND MATERIALS
Days	Cost	Days	Cost	Days	Cost	Days	Cost	D'ys	Cost	Cost
		⅛	$0 44	1⅛	$5 33	15½	$61 78	1	$4 00	$151 99
						1	3 00			3 00
						8¼	25 33	1	3 00	78 00
						3	8 00	1	2 67	84 15
7⅛	$41 40									62 40
2¼	12 67									18 00
9⅛	42 50									67 50
		11	22 00							22 00
						42	84 00			84 00
12⅛	28 00					17⅛	38 36	1	2 25	121 36
2⅛	4 89	6	12 00	23⅜	46 67	149⅜	299 78	23	46 00	1 047 56
				9	15 75					104 23
						10½	52 50			52 50
						6	12 00			12 00
						1	3 50			3 50
							53 00			53 00
									147 30	147 30
	$129 46		$34 44		$67 75		$641 25		$205 22	$2 112 49
		11	$16 50							$16 50
				2⅜	$1 07	11¼	$42 92	1	$3 75	107 00
						8⅜	3 29	2	80	13 87
			$16 50		$1 07		$46 21		$4 55	$137 37
Q'nt'y		Q'nt'y		Q'nt'y		Q'nt'y				
22¼	$30 04									$420 02
5 07	5 58									83 63
13 97	20 96									83 38
						7 05	$9 52			334 39
				27⅜	$34 45					34 45
										19 83
						0 6	3 75			13 50
										111 30
		3.9	$117 00							117 00
						30	3 30			3 30
						4	1 00			1 00
										13 50
						220	11 00			11 00
										4 50
			3 00							3 00
	$56 58		$120 00		$34 45		$28 57			$1 253 80
	$186 04		$170 94		$103 27		$716 03		$209 77	$3 503 66
				2.3%	21 29					
	$186 04		$170 94		$124 56					$3 503 66
	460 sq. yd.		464 sq. yd.		75 cu. yd.					
	$0 40		$0 37		$1 66					

TABLE No. 2.

REPAIRING LINING OF CHELSEA RESERVOIR. — UNIT COSTS (per cu. yd.).

Concrete, lower layer — Mixture 1–2½–6½.

95.5 cu. yds.

Atlas cement,	1.11 bbl. @ $1.35,		$1.50
Sand,	0.39 cu. yd. @ $1.10,		.43
Broken stone,	1.23 tons @ $1.35,		1.66
Lumber for forms,	.014 M ft. @ $21.00,		.29
Miscellaneous expenses, plant, coal, etc.,			1.28
Labor:			
Mixing and placing,		$2.09	
Carpenter work on forms,		.34	2.43
Cost per cubic yard in place,			$7.59

Cement:
1 bbl. cement per 0.89 cu. yd. concrete.
1 cu. yd. concrete per 1.11 bbl. cement.

Sand:
1 cu. yd. sand per 2.55 cu. yds. concrete.
1 load (40 cu. ft.) per 3.77 cu. yds. concrete.
1 cu. yd. concrete per 0.39 cu. yd. sand.
1 cu. yd. concrete per 0.26 load sand.

Broken stone:
1 ton stone per 0.81 cu. yd. concrete.
1 cu yd. stone per 1.03 cu. yds. concrete.
1 cu. yd. concrete per 0.97 cu. yd. stone.
1 cu. yd. concrete per 1.23 tons stone.

1 cu. ft. dust weighs 103 lbs.
1 cu. ft. stone (¾″ to 1½″) weighs 94 lbs.
1 cu. yd. dust weighs 1.39 tons.
1 cu. yd. stone weighs 1.269 tons.
1 ton stone occupies 0.788 cu. yd.
1 ton dust occupies 0.720 cu. yd.

Concrete, upper layer — 1 : 1¼ : 1¼ : 4.

129.2 cu. yds.

Atlas cement,	1.37 bbl. @ $1.35,		$1.85
Sand,	.24 cu. yd. @ $1.10,		.26
Dust,	.32 ton @ $1.50,		.48
Broken stone,	.96 ton @ $1.35,		1.30
Lumber,	.031¼ M ft. @ $21.00,		.65
Miscellaneous expenses, plant, etc.,			1.32
Labor:			
Mixing and placing,		$1.85	
Carpenter work on forms,		.66	2.51
			$8.37

Cement:

1 bbl. cement per 0.74 cu. yd. concrete.
1 cu. yd. concrete per 1.37 bbl. cement.

Sand:

1 cu. yd. sand per 4.28 cu. yds. concrete.
1 load sand (40 cu. ft.) per 6.34 cu. yds. concrete.
1 cu. yd. concrete per 0.23 cu. yd. sand.
1 cu. yd. concrete per 0.16 load sand.

Dust:

1 ton dust per 3.10 cu. yds. concrete.
1 cu. yd. dust per 3.94 cu. yds. concrete.
1 cu. yd. concrete per 0.25 cu. yd. dust.
1 cu. yd. concrete per 0.32 ton dust.

Stone:

1 ton stone per 1.05 cu. yds. concrete.
1 cu. yd. stone per 1.34 cu. yds. concrete.
1 cu. yd. concrete per 0.75 cu. yd. stone.
1 cu. yd. concrete per 0.95 ton stone.

Voids in stone:

Oil barrel filled with stone. Weight of barrel deducted.
Barrel of stone, 742 lbs.
Barrel of water, 510 lbs.
Barrel of stone and water, 942 lbs.

Per cent. voids, $\frac{942-742}{510} = 0.39$.

The following approximate *labor* costs are given:

Transporting, erecting, and removing derrick	$260.85
Equivalent time — foreman, 6 days; engineer, 4 days; laborer, 85 days.	
Transporting, laying, and removing track	125.03
Equivalent time — foreman, 4 days; laborer, 40 days.	
Caring for dump and disposing of surplus by rough grading	70.28
Equivalent time — foreman, 1 day; laborer, 33 days.	

As stated above, the work was planned and carried out under the general supervision of the Engineering Department of the Metropolitan Water Works, of which Mr. Frederic P. Stearns is chief engineer, and Mr. Dexter Brackett engineer of the Distribution and Sudbury departments.

SUPERHEATED STEAM IN PUMPING ENGINES.

BY E. H. FOSTER, M. E., NEW YORK CITY.

[*Read September 15, 1904.*]

Much has recently been said and done about superheating steam as a preparation for its more efficient utilization in driving various forms of steam engines.

As has been frequently remarked, this feature of modern engineering is rather the result of reviving an old art than the introduction of a new principle. Engineers of two or three generations ago were fully aware of the advantages to be derived by superheating steam, but in their efforts to obtain these advantages in practice they encountered certain obstacles which have since been attributed to the primitively crude condition of the steam engine and to the lack of such proper facilities as are in common use to-day, such as mineral oil for lubrication, improved stuffing-box packing and steam-pipe gaskets.

A most natural question would be: If superheating has been found so useful, why is it that we only now approach the subject very much as if it were a novelty? We have indulged in the foregoing remarks for the purpose of providing an answer to this question.

The scantiness of opportunities for installing superheaters naturally hindered designers and builders from bringing the apparatus to a high state of development. It is only by repeated execution that even the most obvious improvements may be devised, and it may be said that in this country at least the superheater was waiting on the steam engine and the steam engine was waiting on the superheater, without their being used together until the advent of the steam turbine as a commercial machine, which certainly must be recognized as presenting a great opportunity for the development of the superheater.

With the steam turbine there seems to be no doubt that it is highly important to have the steam superheated, and provision

has been made for this in all the important plants which have been and are now being installed. This competition has naturally spurred our engine builders to the point of asking why their engines are not as suited to superheated steam as is the steam turbine.

In looking about for experience it has been found necessary to go to Europe for the greatest number of practical examples. The inducement of more expensive fuel has probably had much to do with European progress in this direction.

While it has not been found possible to transplant to this country European practice *in toto*, we have undoubtedly been considerably aided by studying these methods. It was in the study of this question in Europe that our attention was first called to the adaptability of the superheater to water-works engines, and this is the point which we wish to emphasize more particularly in this paper.

No form of steam plant could be better adapted to the use of superheated steam, and in no more simple way can pumping-engine duties be surely improved.

An interesting work on water supply published by the Indian government is the "Roorkee Treatise on Civil Engineering," Vol. II, Section xii, 1902 edition. M. D. W. Aikman, the author, remarks in describing superheaters:

"The advantage of superheating steam before utilizing it in the engine is to increase the efficiency of the engine from 8 to 12 per cent. Superheating is effected by conveying the steam from the boiler or steam drum through the furnace before sending it on to the engine. The cast-iron pipe conveying the steam through the furnace is made U-shaped, so as to give the steam a long distance to travel in the furnace. This pipe has circular lugs cast round it (close together) outside, and longitudinal lugs inside, so that the radiation of heat from the furnace to the steam may be as much as possible. By superheating steam its volume is increased whilst its pressure remains unchanged. Also the many particles of water carried from the spray of the boilers are converted into steam. If these particles of water are not converted into steam, they not only do no useful work, but they cause considerable annoyance in the working of a steam engine by what is technically called 'priming.'"

These words are amply corroborated by a number of tests

which have been made on various forms of pumping engines, among which may be mentioned the triple-expansion Sulzer engine at St. Galles, Switzerland, the triple-expansion Worthington engines at London and St. Albans, and the vertical triple-expansion crank and fly-wheel engine at Grand Junction Water Works, England, and the twenty Worthington horizontal triple-expansion high-duty pumping engines on the great Coolgardie pipe line, Western Australia. Sufficient data have already been obtained in this country to corroborate the figures obtained in Europe, and tests have been made at the water works at Norfolk, Va., Brooklyn, N. Y., at two main pumping stations in Chicago, Ill., and at the two high-service stations in New York, on engines of various sizes and conditions of service. In all cases it appears that superheated steam was attended not only by the desired steam and fuel economy, but by most satisfactory results in the handling and operation of the machines.

Further data will be forthcoming before very long, as the Allis-Chalmers Company are installing superheaters in connection with the three 25 000 000 gallon vertical triples they are erecting at the North Side Station in Chicago. R. D. Wood & Co. are also putting in two separately fired superheaters to serve the four 30 000 000 gallon triple-expansion crank and fly-wheel engines which they are installing at the new low-service pumping station in Cincinnati. When this paper was undertaken, it was hoped that some of the figures which would naturally be forthcoming from the tests of these plants would be available by this time.

Data with reference to such tests as have been made in this country may readily be obtained by those interested.

A most elaborate test was made on each of the six 20 000 000 gallon vertical triples at Chicago by a board of experts, and the results published in *Engineering News*, May 6 of this year.

Although there is considerable variation in the duties given by different engines of the same size, it has been established that the remarkable showing made by these engines is due entirely to superheated steam, and that the amount of superheat bears directly on the duty.

The writer contributed to the American Society of Mechanical Engineers in 1899 some figures obtained in a series of very care-

ful tests of a low-duty triple-expansion Worthington engine of 100 horse-power on intermittent service.

Last winter a series of tests was run at the New York City water works, and made the object of a thesis by Messrs. H. S. Brown and J. F. Muller, students at Cornell University. These tests were very carefully supervised by Professor Carpenter, and some very interesting results were obtained.

We extract the following:

Conditions.		Duty per 1 000 lbs. steam.
Saturated steam	All cylinders jacketed.....	138 mill.
Steam superheated 47.3 degrees.	All cylinders jacketed.....	151 mill.
Steam superheated 80 degrees ..	L. P. cylinders only jacketed	155 mill.

But possibly the most interesting and practical of all tests is one made by the city of Brooklyn during the early part of this year in connection with the pumping station at Spring Creek, which is one of the points where ground water is delivered into the conduit. This station is an old one, having been in use for ten or twelve years, and is equipped with two Knowles compound, condensing, direct-acting duplex pumps, size $6\frac{1}{2}$ and $11\frac{1}{2} \times 16 \times 24$, and one Davidson triple direct-acting condensing pump, size 18 and $24 \times 24 \times 24$ inches. Each pump is equipped with an independent jet condenser, the exhaust steam of which is used to heat the feed water. The boilers are of the horizontal return tubular type, 60 inches in diameter by 15 feet long, with 76 3-inch tubes or 915 square feet of heating surface and 25 square feet of grate surface. White-ash anthracite coal in large size is burned with natural draught.

This test was made by equipping one boiler with a superheater and running a series of alternate tests with each boiler independently. It was desired to know just how much fuel could be saved in a station of this character under its regular working conditions. The results were most satisfactory.

The first tests were made by the contractors with the city engineer, of twenty-four hours each, both with saturated and

superheated steam. The results were a saving in coal per foot-pound of work done of 20.2 per cent., and saving in feed water of 23.2 per cent. The average temperature of steam on leaving the superheater was 527°, corresponding to a superheat of 207°, since the steam pressure was only 80 pounds per square inch.

These tests were most conclusive, but the supervising engineer thought to convince himself still further as to the value of the device and made a five-day test under average working conditions with superheated steam, following this by a five-day test under similar conditions with saturated steam. He reported a saving somewhat in excess of those obtained on the official test.

The plant offered such inducements for scientific investigation that three students from the Stevens Institute selected this as a subject for their joint thesis, and a series of tests were made under the direction of Professor Jacobus and Professor Pryor. The results obtained on these tests showed a remarkable saving, due to the introduction of superheated steam, as follows:

	Saturated Steam.	Superheated Steam.	Increase PerCent.
Duty per 100 lbs. coal as fired	19 888 784	24 532 704	17.4
Duty per 1 00 0000 B. T. U.'s supplied to pumps	23 503 690	27 864 280	18.5
Total ft. lbs. of work per pound of coal as fired	421 344	508 808	18.1
Total ft. lbs. of work per pound of combustible	519 984	640 944	23.0

There seems to be no doubt about the perfect demonstration of the great value of this device in this instance, and it is of especial interest to know that no change whatever in the character of the oil or packing, or steam pipe gaskets, or any other features of the plant were made; but it was kept in the same condition as it had been running for several years.

A recent inquiry as to the conditions at the station reveals the fact that the good results are continuing. It also develops that when cleaning the superheating boiler it is necessary to run the plant with saturated steam, but that the steam is changed from saturated to superheated, and vice versa, with impunity, and no

objectionable results. It is planned by the chief engineer to attach a superheater to the other boiler at this station as soon as possible.

The advantages of superheating may be classified under three heads:

First. A reduction in initial cost of the plant if designed for superheated steam, or an enlargement of the power of an existing plant.

This reduction consists in the employment of a more simple form of steam engine to do a given amount of work and give a specified duty, and the simplification is in the omission of such devices as are rendered superfluous by the use of superheated steam, such as steam jackets and separators. Another example of the simplification thus rendered possible would be the use of a compound engine in place of a triple or of a simple in place of a compound, the superheater supplying the economy which is otherwise effected by multiplicity of cylinders.

The increase in power by introducing superheat is chiefly recognized in the greater capacity given the boilers; for instance, it is frequently found in practice that by the introduction of superheaters in a plant requiring four or five boilers to operate, at least one of these units is put in reserve; thus in considering the extension of boiler capacity, there will always be the alternative of installing superheaters.

Superheating also materially affects the question of steam-pipe sizes. For many unfounded reasons it has been the custom in this country to gradually increase the size of steam pipes, until in some instances they are of really ridiculous proportions. The development should have been in the other direction. As steam pressures and revolutions per minute are increased, it is unnecessary to use such large pipes, and many peculiarities of our steam indicator diagrams which have been laid to too small a steam pipe have been proved to arise from other causes. Tendency to higher velocities in steam mains, which means the use of smaller pipes, is undoubtedly very marked, and this tendency is considerably aided by superheating, as a lighter gas will travel in the main with higher velocity without the same loss of pressure due to friction.

Second. The increase of engine duty due to the elimination of cylinder condensation and the greater efficiency of the steam when superheated. As a result of comparing efficiency tests and the conditions under which they were made, we have prepared a brief table of the saving which might reasonably be expected from the use of superheated steam in various types of engines as distinguished by the duties which they perform in foot pounds per million heat units.

Duty of Pumping Engine.	Saving by 100° Superheat.
150 000 000	6%
100 000 000	10%
50 000 000	20%
10 000 000	40%

Third. The general improvement in the conditions of starting and operating the engine. This is a point which cannot be so easily measured in dollars and cents, but one which is of great importance nevertheless.

With superheated steam in the engine it responds more quickly to the action of the governor and cut-offs; it is a machine which is more easily controlled because of the lack of water in the cylinders and steam pipes; it is easier to keep clean externally, while the internal parts are well preserved, and piston lubrication is rendered more efficient owing to the lack of water in the cylinders.

We want superheated steam on this account just as we want our engine rooms and our attendants kept neat and clean, and just as we want a fine brick or stone building for an engine house and well-kept grounds, instead of a ramshackle wooden shanty surrounded by rough grounds, such, for instance, as would be found at an oil-well pumping station.

We heard an erecting man of one of our largest engine-building concerns recently commenting on his first experience in starting up an engine with superheated steam. He said that he had never had so little trouble with a new engine, and whatever the advantages of fuel consumption might be, he was convinced that superheated steam was good for the engine from the operator's point of view.

Pumping engines which are called upon to assume suddenly increased loads are greatly benefited by superheating the steam,

as they are thus enabled to respond more quickly and more fully to the demand for extra work.

The same effect from superheating has been observed in electric power stations when a peak occurs in the load, and more particularly in locomotives, where careful tests have demonstrated that those equipped with superheaters lose much less time in getting under way from stations, and take the excessive grades more easily.

The means for obtaining superheated steam must depend largely upon the conditions at hand.

An ideal arrangement would be to have a separately fired superheater in which the superheat can be regulated carefully to suit the requirements of the conditions. (Fig. 1.)

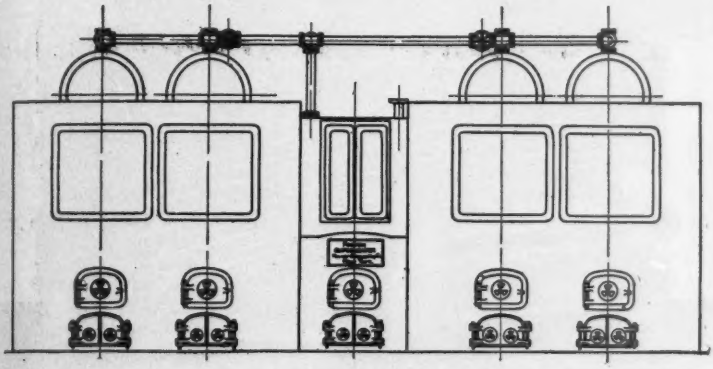


FIG. 1. ARRANGEMENT OF FOSTER SUPERHEATER WITH SEPARATE FURNACE, SET BETWEEN TWO BATTERIES OF BOILERS, SHOWING MINIMUM SURFACE EXPOSED FOR RADIATION AND DIRECT PIPE CONNECTIONS.

The principal objections to the separately fired arrangement are the possible complication in steam piping, or the loss of heat due to radiation. As to the former, it may be said that the objections are really very slight, as it has been found that with a little care a simple and efficient system of piping may be worked out, which will answer all the requirements as to safety and convenience, whereas the external radiation from the superheater setting is overcome by placing the superheater between or close

up to the setting of the boilers. A very good arrangement for a separately fired apparatus is to assume, for instance, a battery of four boilers, one of which is in reserve, and install a superheater large enough to superheat the steam from three of the boilers, and place the superheater in between the two batteries. This arrangement makes very simple piping and utilizes the space to the best advantage. It is possible to arrange a superheater in this location without interfering with the openings for blowing

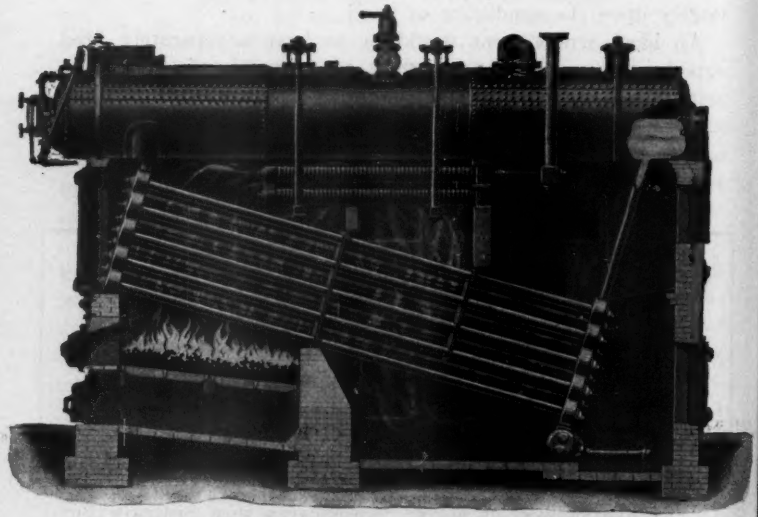


FIG. 2. FOSTER SUPERHEATER COMBINED WITH B. & W. BOILER.

the boiler tubes. The convenience of placing superheaters in such a position as to utilize part of the heat of the boiler gases has led to the development of what may now be considered as well-known standard arrangements, which are illustrated by the accompanying figures.

For instance, for a horizontal water tubular boiler with inclined water tubes and a horizontal drum, Fig. 2, a most convenient point for locating the superheater has been found just under the drum and above the tubes, the steam being drawn from the dry

pipe in the usual manner and passed through pipes into the superheater, and carried out at a point near the original boiler outlet.

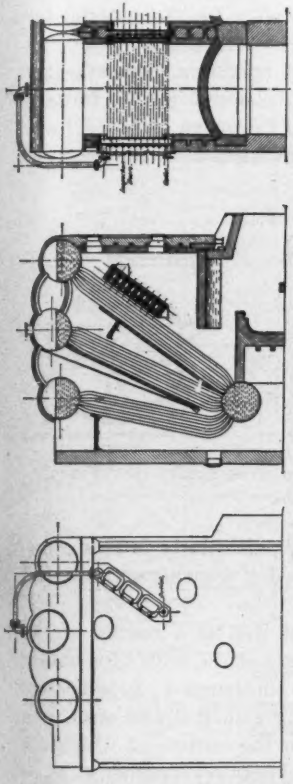


FIG. 3. FOSTER SUPERHEATER COMBINED WITH STIRLING BOILER.

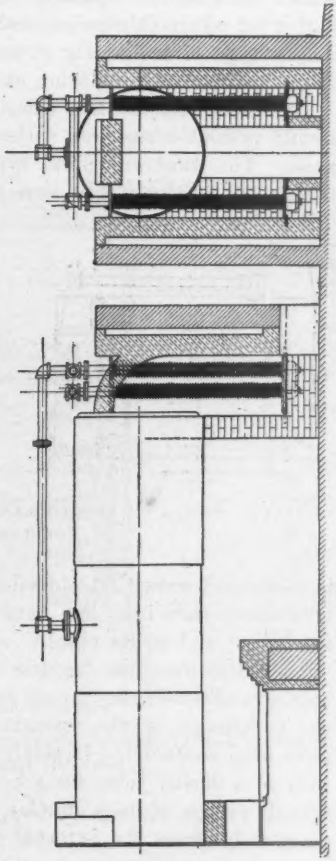


FIG. 4. FOSTER SUPERHEATER COMBINED WITH HORIZONTAL RETURN TUBULAR BOILER.

In horizontal water tubular boilers with inclined drums there is not sufficient space between the drums and the tubes for the location of a superheater, and it has been found necessary to

leave out one or two horizontal rows of tubes about the middle of the boiler to provide a space for the superheater.

In the vertical bent tube boiler, Fig. 3, a space for the superheater is found immediately over the furnace arch, while in horizontal return tubular boilers, Fig. 4, and the internally fired marine type of boiler, Fig. 5, an ideal place for the superheater exists in the rear combustion chamber.

To insure long life and efficiency of operation a superheater should present a cast-iron surface to the action of the furnace gases. The most successful types in European practice have been made wholly of cast iron, but this method of construction

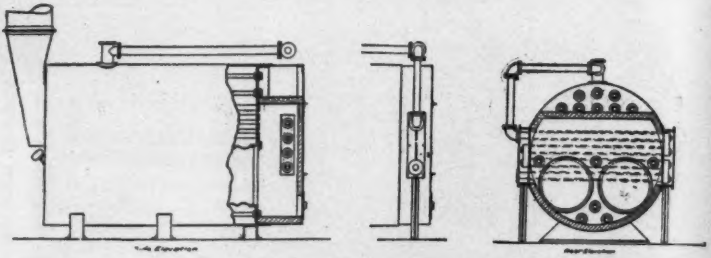


FIG. 5. FOSTER SUPERHEATER COMBINED WITH INTERNALLY FIRED TUBULAR BOILER.

is considered somewhat objectionable, particularly in this country, where cast iron has been proved a treacherous material for boilers and steam pipes.

To utilize the good features of cast iron as a resister of the corrosive effects of the furnace gases, and at the same time obtain the advantages of the wrought-steel construction, superheaters have been constructed largely by using a solid drawn-steel tube such as a Shelby tube, for a body, on the outside of which are shrunk a series of deep annular gills, closely set together so as to completely cover the external surface of the tube and protect the same from blistering or corrosion, as shown in Fig. 6. This results in a form of tube with deep external corrugations, giving an extended surface for the absorption of heat, and giving greatly increased strength to resist bursting strains. The in-

ternal surface of the Shelby tube being particularly smooth, steam may be passed through it at a very high velocity without undue friction losses, and in the form of superheater now being described this velocity is insured by annular distribution, consisting of internal filling tubes placed within the main tube

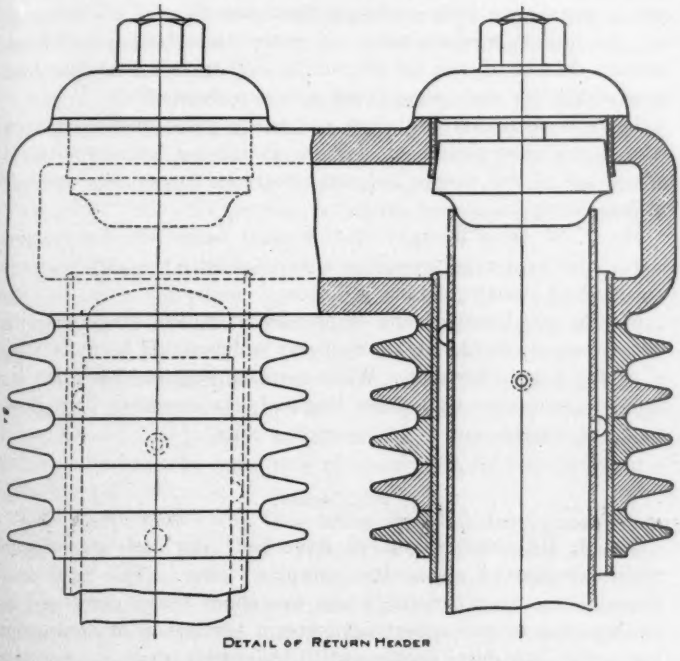


FIG. 6. DETAIL OF FOSTER SUPERHEATER SHOWING CONSTRUCTION OF ELEMENTS AND HEATERS.

and held centrally so as to provide annular spaces for the passage of the steam.

The tubes are joined at their ends by expanding them into wrought or cast-steel headers and return boxes, and are arranged so as to give flexibility.

This form of construction has been successfully applied to

several thousand horse-power of boilers and has been utilized in a number of independently fired superheaters, and is apparently meeting the requirements of durability and efficiency.

That the superheater is already well beyond the experimental state needs no greater proof than a recent report of the United States consul in Germany, to the effect that its use is now general in connection with engines in that country, and a statement by the largest manufacturers of water tube boilers in Great Britain that of all the boilers which they turned out last year over eighty per cent. were fitted with superheaters.

There is no reason why each and every water-works engineer who is not using superheated steam should not take immediate advantage of this simple and comparatively inexpensive method of increasing his engine duty.

Mr. F. W. Dean brought up this point before the Association last winter as a very promising and practically the *only* remaining method in sight of raising duties.

We do not know of any improvement which would require less attention, nor do we know of any which would be more sure of giving a good account. What more appropriate place for its rapid introduction than New England, the home of high-class pumping engines and of low pumping costs?

DISCUSSION.

MR. J. HERBERT SHEDD. I have had very little experience with superheated steam for pumping water. The first and almost the only experience I had was about thirty years ago in undertaking to run superheated steam through a Worthington horizontal low-duty engine, with the result that we set the wooden lagging on fire. We didn't pursue the experiment.

THE PRESIDENT. It would really seem as though the ordinary duplex engine was one of the machines which was best suited for the use of superheated steam. Certainly if its duty can be increased thirty or forty per cent., as mentioned in the paper, a very promising field is opened.

MR. EDWARD ATKINSON. Mr. President, the danger of fire is not confined to the danger from superheated steam. The heavi-

est loss that the factory mutual companies ever suffered came from the most unexpected cause, and that was the sudden bursting into flame, almost an explosion, of the wooden lagging of a 10-inch cylinder of a compound engine, as the result of which the three Warren Mills were totally destroyed, with the contract made, the pipes on the ground, but the sprinklers that would have stopped the fire where it originated not put up. Beware of wooden lagging on any boiler or cylinder anywhere, superheated or low-heated, or otherwise.

MR. W. C. HAWLEY. Mr. Foster mentions the possible saving with engines running at various duties. I would like to ask at what steam pressure he would start in making those savings, and whether such a saving would be a possibility with an initial pressure of 175 or 200 pounds, which is sometimes carried in large pumps.

MR. FOSTER. I will say, without having elaborated that point very much in the paper, that the idea would be to expect those duties with the steam pressures for which the engines were designed. For instance, an engine of 150 000 000 duty would naturally have a high steam pressure, say of 150 pounds, and an engine of 40 000 000 duty would not usually carry more than from 100 to 125 pounds. It is expected that those pressures would automatically take care of themselves in considering the question generally.

THE PRESIDENT. The idea being that low-duty engines are very much more benefited by superheating the steam than the high-duty engines, and in the case of a direct-acting pumping engine, such as the duplex engine, the duty could be increased enormously without the introduction of new boilers by superheating the steam. That is the idea, isn't it, Mr. Foster?

MR. FOSTER. Yes, sir; that is the idea.

THE ADVANTAGE OF A SCIENTIFIC BASIS FOR DETERMINING THE VALUE OF FUELS.

BY HENRY J. WILLIAMS, CHEMICAL ENGINEER, BOSTON, MASS.

[*Read December 18, 1904.*]

The question of testing coals by analysis and calorimeter test, to determine their value, as well as by boiler test, is an important one, which is of interest to-day to the engineer and to the large purchaser of coal quite as much as it is to the chemist, for the realization is slowly coming home to us that coal cannot be economically used for making steam unless we know accurately its quality or intrinsic value in addition to knowing simply its name and its cost per ton.

Too many false notions about coal which lead to erroneous conclusions are unfortunately held at the present time, much of the confusion doubtless arising from the fact that the knowledge which we possess about the different coals, or one particular coal as it is shipped from different mines, is incomplete or inexact, and is not at all conclusive in consequence. The question is often asked, "But how are we to reliably know what we are getting?" Science, and science only, can answer that question. Science is, after all, but systematized knowledge, with all errors, wherever possible, detected and discarded. We are far more likely, therefore, to know what we are about, in purchasing coal, if we are guided by the facts which we know to be true, rather than if we permit ourselves to be influenced by opinions which are unsound and facts which are incomplete.

A discussion of certain aspects of this problem, from the point of view of one who has conscientiously labored for many years in attempts to discover what is unsound and remedy much that is untrue, may prove of interest, and it may serve to suggest a practical way out of our difficulties.

The values which we actually realize from coal, in the form of steam or work, depend first upon the nature, composition, and

fuel value of the coal, which are best determined by the chemist who makes a specialty of such work, and second, upon its behavior during combustion, which the engineer controls. But the process of combustion is as intimately connected with chemistry as it is with physics, so that an exact knowledge of the manner in which combustion proceeds is only to be gained when the engineer and the chemist work together. Such troubles, for instance, as excessive or insufficient draught, imperfect combustion, leakages of air above or through the fire, improper sizing of the coal, excessive thickness of fire, improper grate area for the amount of steam produced, too slow combustion, etc., are all readily detected by a correct interpretation of the results of accurate flue gas analyses, and the proper remedy then suggests itself. Such information, promptly utilized, serves to reveal and at once remedy the disadvantageous conditions of burning which would otherwise continue undetected, and many times even unsuspected.

The boiler test, taken by itself, on the one hand, tells us but little about the intrinsic value of a fuel, for it is subject to many inevitable losses of heat which occur from various causes and which vary widely with different furnaces. By slightly varying the conditions we can obtain, at will, in the same furnace, either a good or a bad result, with precisely the same coal, so that the final results, at best, may be quite deceptive, and nothing definite about the true value of the coal, as a fuel, is really learned.

The analysis and calorimeter test, on the other hand, while they do not tell us how to handle or burn the coal, unquestionably serve to fix *definite* and *invariable standards* to go by, towards which we may strive. When properly made they tell us accurately and positively with just what kind of coal we are dealing, the exact number of heat units which its complete combustion will yield, the percentages of moisture, volatile matter, fixed carbon, ash, and sulphur which the coal contains, and the influence of the latter upon the heating power. If carried far enough they reveal also the ultimate composition of the coal, the nature of the ash, its fusibility and other properties. With this information we are enabled to select a suitable fuel for almost any kind of work with adequate knowledge of what we are about, but it is the height of folly to rashly conclude that all chemical analyses

are of no value simply because an incomplete analysis of a coal fails to tell more than it is capable of revealing, and yet this is what is frequently done.

A poor coal, of low heating power, is sometimes said, with some degree of truth, to yield higher results under a certain boiler than a better coal, of the same nature but of greater heating power, and the erroneous conclusion is confidently reached *that the better coal is of inferior quality*. This surprising though all too frequent conclusion is solely due to the fact that some important factor has not been taken into account, and it affords another instance of the folly of drawing conclusions from insufficient premises. The heat value of a unit of carbon or of hydrogen is practically the same in all coals of the same nature, but the better coal may have been lump coal, which left spaces beween the lumps when placed upon the grate, while the poorer fuel consisted of fine screenings which packed closely and left no such spaces. In consequence, a leakage of air occurred between the lumps of larger coal, which cooled the fire and reduced its efficiency. Stopping this leakage of air, which occurred in the one case and not in the other, would have been all that was required to actually realize and apply the greater heating power of the better coal. The conclusion formerly reached would then have been reversed.

The above illustrations seem plainly to indicate that the results of boiler tests, unaccompanied by chemical analyses, are deceptive, because the conditions under which they are made are largely unknown quantities, or can, at best, only be surmised. When these tests are accompanied by reliable analyses and calorimeter tests of the coal and properly interpreted analyses of the flue gases, the conditions under which they are conducted cease to be unknown quantities and their results become definite, convincing and conclusive.

It is sometimes the custom for the engineer to make the flue gas analyses himself, and occasionally the analysis and calorimeter test of the coal also. As a general rule this practice is not to be recommended, for, while the results which he obtains may sometimes be better than no results at all, the conclusions are quite likely to be faulty or deceptive, owing to his insufficient experience or necessarily limited knowledge of chemistry. This

work is entirely out of his line and he is generally too busy about other matters during a boiler test to do it properly.

The results of reliable analyses and calorimeter tests of coal, which are definite quantities, seem also to furnish all the information that is required to enable us to purchase coal intelligently and on a definite basis. But it is of vital importance, if we are to be guided by the results of such tests, that their accuracy should be beyond question, and it is an unfortunate fact to record that, owing to the woefully incomplete knowledge about coal which is generally possessed and to defective calorimeters, much of the work which is being done to-day, in this line, is none too good.

Conscious of the many shortcomings on this side of the question, the writer has left no stone unturned in efforts to overcome them.

Investigations have now been carried on for nearly ten years to improve our methods of conducting analyses and calorimeter tests and to accumulate reliable data about all kinds of coal which should reveal what is true and what is false. Briefly outlined, this work has included:

1. Complete proximate and ultimate analyses of more than three hundred different American coals, together with calculations of their theoretical heating powers.

2. An exhaustive investigation, lasting two years and a half, to discover reliable methods for determining moisture in coal, including more than two thousand separate determinations.

3. A study of modern calorimeters and of the errors to which they are liable.

4. The production of a perfected form of bomb calorimeter that should be free from all such errors and as accurate and convenient to operate as mechanical skill could make it.

5. Accurate calorimeter tests of all of the above coals.

Many other kindred subjects have been investigated, and numerous machines, forms of apparatus and methods of examination have been devised, constructed, and made use of, to make it possible to bring the investigation to a successful issue. A slight outline of the scope of this work is all that can here be given, but it is now practically completed and the writer expects to publish it in full, in book form, at the earliest opportunity.

Sufficient reliable data seem to have been collected, however, to bring the difficult question of "coal," which here confronts us, under fair control.

Coal, as it occurs in the seam, is seldom free from partings of slate, "bone," or inferior coal, which it is the duty of the miner to sort out; but, for one reason or another, this is seldom perfectly done, particularly where the seam becomes thin, and, as a natural consequence, a great many different grades of genuine coal of the same name, but from different mines or places, find their way to market. That this is the case, the following facts, taken from the writer's experience, seem conclusively to show:

A certain coal, in common use, whose name is omitted for obvious reasons, generally carries on an average 6.58 per cent. ash, this result being the average of more than twenty analyses of this coal, as it occurs in the market, made by the author in connection with boiler tests. He has also analyzed fair samples of this coal showing 8 per cent., 10 per cent., 14 per cent., and recently over 22 per cent. of ash. Is it possible, in the face of such evidence, to still believe that *the name* of this coal is any guarantee of its quality?

What is true of this coal it true of many others. The one cry of suffering consumers is: "Give us coal of *uniform* quality," but do they get it, at any price?

The writer some years ago had occasion to analyze a great many samples of turpentine, as it occurs in the market in some sections of this country. The results were most interesting. Carefully interpreted they seemed to suggest that the manner of selling turpentine is based on the fact that turpentine is worth 45 cents per gallon and naphtha 10 cents.

The drummer is told to "get orders, — at *any* price," and brings in quite a variety. The goods are then sent out as follows:

The man who pays 45 cents per gallon gets — straight turpentine (if he is lucky).

The man who pays 41½ cents per gallon gets — 90 per cent. of turpentine and 10 per cent. of naphtha, nicely blended.

The man who pays 39¾ cents per gallon gets — 85 per cent. of turpentine and 15 per cent. of naphtha, also nicely blended.

The dealer is contented because his profit is *just the same on*

all orders, and the customer is happy because he has bought his turpentine *below market price*. But has he?

Returning to the subject of coal, is it reasonable to suppose that, where there is a Yankee at both ends of the bargain, the customer who is unwilling to pay what good coal, or anything else, is worth, gets any better coal, or anything else, than he pays for? We think not.

Unfortunately this admirable adjustment does not always take place, and the sinners are not the only ones that suffer from poor coal of irregular quality.

Verily the world doth move. Does it not, therefore, seem reasonable to suggest that a system of purchase, based upon the *quality* and *heating power* of the coal, which are fixed quantities determined by analysis and calorimeter test, that would insure to the consumer a *uniform quality* of coal, for a *definite* price, and to the coal dealer *proper return* for his poorest as well as his best grades of coal, would be fair and equitable to *both* and would have many advantages to recommend it?

Such a system seems to the writer to be the only fair and logical way of dealing with this perplexing question, and it is a fact that wherever it has been properly tried it has given satisfaction, while in some places the bills have even been cut in two.

It is essential in all tests of coal that the sample operated upon should fairly represent the whole of the coal under investigation, otherwise the best work of the chemist is of no avail and the results are misleading. To do this successfully, however, requires skill, judgment, and experience and a faithful adherence to certain fundamental principles of correct sampling which are too seldom observed. It is almost needless to point out that to pick out a few small lumps, here and there, and to put in a few pieces of "bone," even if judgment (?) is used, is radically wrong and violates a vital principle of all correct sampling.

Owing to the various conditions under which coal is found, sometimes in lump form, sometimes fine, sometimes a mixture of the two, with more or less slate interspersed, sometimes in the yard, sometimes in the bins, sometimes on the cars or in the barge, it would be hopeless, in a brief paper, to attempt to lay down hard and fast rules which would apply to all cases. A few sug-

gestions only can be offered in illustration of the fundamental principles which govern all sampling, which should ever be kept in mind. These are:

1. To completely eliminate the personal factor of choice or selection.

2. To secure sufficiently large individual samples of uniform size, including lump, fine, bone, etc., from a sufficient number of different places, equidistant from each other, and representing all parts of the pile. This yields a reasonably fair average of the whole pile.

3. To unite and crush all the coal taken out to a uniform size, particularly the hard lumps of slate, mix with the utmost thoroughness on a clean floor, make into a pile, flatten this down and quarter evenly, throwing out two diagonal quarters perfectly clean, then repeat the above process, pulverizing finer and finer, until a sample of twenty-five pounds or less remains, the whole of which should be preserved for analysis.

The application of these rules, under varying conditions, calls for much ingenuity and skill, which can only be gained by experience, but a fair sample of the coal can almost invariably be secured in this manner, the reliability of which can readily be confirmed, in very important cases, by repeating the sampling from an equal number of different places.

The writer recently had occasion to sample in duplicate some 15 000 tons of New River coal, lying in the yard in a pile 12 feet broad, 20 feet thick and 150 feet long. The top of the pile and one exposed end were the only points accessible. This coal had been sold for " New River coal," but the mill manager claimed that it was not, that it gave bad results, etc., and refused payment except at an unwarrantable discount.

A brief description of how the sampling was done will illustrate the manner in which the above rules were complied with.

Starting on top, at the rear, ten stakes were put in, to mark ten spots fifteen feet apart; then, to eliminate the personal factor of choice, the surface coal was shoveled out level at each spot to a depth of four to six inches. With a pick the coal was uniformly broken up at each spot to an additional depth of about four inches over an area three feet square, and after very

thorough mixing of the loosened coal three large shovelfuls were taken from each hole. A half shovelful or less of surface coal was also taken between each of the ten holes. Then, proceeding to the face of the pile, the outer coal was removed and three shovelfuls were taken from each of four spots five feet apart, situated at different levels.

The whole of this coal, representing about six hundred pounds, was then dumped upon a clean floor, all the lumps broken, thorough mixture effected, and the quartering down process applied. Two samples, taken one after the other, from different sets of holes, in the above manner, yielded by analysis:

Sample No. 1.	Sample No. 2.
Ash.....6.07 per cent.	Ash.....6.15 per cent.

The difference is only .08 per cent., so that either sampling can be considered reliable. Other confirmatory results were obtained, and the writer was able to state, with good grounds for his belief, that the coal in question was " New River coal," and that the complaint which had been made had no foundation in fact. Settlement in full for the coal was made within three weeks, so that further comments seem unnecessary.

Where sampling has to be frequently performed a small jaw crusher, of the Blake type, is very desirable, as it greatly hastens and simplifies the work and makes it more reliable. Various devices are also in use to avoid the necessity for the laborious and somewhat unreliable quartering. When samples are reduced to three eighths of an inch and finer, an improved form of the well-known tin sampler, which the author has perfected, reduces the labor of handling to a minimum, avoids all errors due to imperfect mixing and greatly increases the reliability of the samples. The ordinary sampler consists of a stiff metal frame provided with narrow longitudinal troughs, set parallel, between which there are open spaces of the same width, through which the material can fall. When the sampler is full it must be lifted and emptied, which with coal is a very dirty operation. The improvements which have been made consist in setting the frame firmly, at an angle of forty-five degrees, over a barrel, in an inclined support, which also serves as a cover for the barrel, and

in leaving the lower end of the longitudinal troughs open, so that they can clear themselves; also in providing an apron, at the lower end, to catch and guide the coal to a pan, as it slips down. This device is shown in Fig. 1.

The coal, which should be of a uniform size, is simply delivered in a thin sheet upon the face of the sampler, with a flat shovel. One half of it drops through into the barrel, where it requires no further handling, while the other half, which has been caught in the inclined troughs, simply slides down by its own weight into a pan provided to receive it. A sample of fifty pounds of coal, crushed to three eighths of an inch, can be accurately cut down to about twelve pounds in a few minutes, by simply putting it through the sampler twice. It can then be crushed much finer, and similarly cut down in a smaller sampler of the same type.

FIG. 1. SAMPLER.

The final sample should invariably be crushed and ground to pass an eighty-mesh screen, and should then be kept in tightly stoppered bottles.

Having obtained a fair sample of the coal the next step is to determine its calorific value. The merits and defects of the various calorimeters that are at present in use cannot here be considered, further than to say that practically all of them are worthless while one or two yield results that are, at best, only approximate.

The bomb calorimeters in which the combustion takes place in an atmosphere of oxygen gas, under pressure, are the only ones

that can lay claim to a fair degree of accuracy. The best known of these is the Mahler bomb calorimeter, brought out in 1893, a modified form of Berthelot's original calorimetric bomb. This has been, in some respects, improved upon by Atwater.

Mahler's apparatus consists of a bomb of forged steel whose exterior is nickel plated while its interior is coated with a thin lining of enamel which serves to protect the interior walls against the corrosive action of the acids which are formed during the combustion.

The coal to be tested is placed in a shallow platinum pan attached to the end of a light platinum rod which hangs from the under surface of the lid of the bomb, and it is in contact with a fine iron fuse-wire, which is connected to another similar rod. The fuse-wire may be kindled by means of an electric current and its combustion serves to ignite the coal. A heavy lid screws upon the outside of the neck of the bomb, and the latter can then be charged with about twenty-five atmospheres of oxygen gas, introduced through a long stem or pin valve, extending above the bomb, and closed by means of a thumbscrew. The bomb is placed in a calorimeter-can where it is partially covered with from 2 200 to 2 400 grams of water, which is stirred by means of an agitator, operated by hand with the aid of a lever. The combustion is instantaneous and complete, and the heat generated passes from the bomb to the water of the calorimeter, where it is measured. The calorimeter-can, which receives the bomb and the water used, is set within the customary water-jacket, which is intended to protect it as much as possible from draughts and the variable influences of the surroundings.

Accurate as the above instrument is in principle, there are numerous sources of error, which seem to have been overlooked, and many annoying defects of construction, which are serious. Aside from these, however, the errors which occur are, for the most part, small, while some of them are negligible. But, in the opinion of the writer, it is unwise to say that any error which can readily be prevented is negligible simply because such an error is small.

The defects of the apparatus appear to be the following:

1. The enamel lining, being a poor conductor of heat, causes

a trifling error from that cause; moreover, owing to the unequal expansion between enamel and metal, to which the apparatus is subjected when in use, it soon peels off. After about twenty combustions, imperceptible cracks occur which soon grow larger, corrosion sets in and the lining ceases to prevent the gradually increasing errors due to this corrosion.

2. The lid or cover, which screws upon the exterior of the neck of the bomb, is, of necessity, very heavy. It depends, for a tight joint, upon the sliding contact of an annular tongue of metal, projecting from its under surface, upon a ring-washer of lead, placed within a corresponding slot on top of the neck of the bomb. This method of sealing is somewhat defective and it does not invariably yield a tight joint.

The crushing of a lead washer, at the bottom of a slot, frequently also makes the cover bind, owing to the flow of metal.

3. The bomb is only partially immersed, even though as much as 2 400 grams of water have been used, so that losses of heat by conduction and radiation through the projecting stem must inevitably occur. No accurate correction for such losses can be made.

4. The amount of water employed, to only partially cover the bomb, is much too large, so that the range of temperature obtained, for a given unit of fuel burned, is smaller than is desirable.

5. The stirring of the calorimeter by hand is both awkward and tedious. It is well nigh impossible for a single operator to properly stir the calorimeter and take readings of the thermometer, on time, to one one-hundredth of a degree or closer, with any degree of certainty or accuracy. The stirring must be kept up for at least fifteen minutes and necessarily proceeds at a somewhat irregular rate, so that no correction for frictional effect of the stirrer can be correctly applied.

6. The crucible which holds the charge is too shallow, so that losses of coal by scattering, when oxygen is being admitted, or by spilling, owing to the vibration which may occur while the cover is being screwed on, are of frequent occurrence. These losses of fuel are not readily detected, so that errors resulting therefrom may occur and not be known.

Other minor defects also exist, such as the disadvantage of having to dip one electric wire under the surface of the liquid, in firing the bomb, while the other is touched to the bomb, and the disadvantage of employing an iron fuse wire for igniting the charge, which does not invariably burn to the same oxide, and whose heat of combustion must, therefore, be more or less uncertain; also the disadvantages due to miss-fires, which occasionally occur.

Finally, all open calorimeters are liable to errors due to exposure to the variable influences of the surroundings, whose temperature during an observation *can only be known approximately*. An error is also caused by evaporation of water from the surface of the open calorimeter-can, which, though small, can be avoided. The custom of only stirring the water jacket occasionally is also objectionable, as the temperature of this jacket varies at different points and cannot be accurately known. All corrections based upon such inaccurate readings must, therefore, leave much to be desired.

The above defects are, many of them, small, but some of them are important, while all of them can be remedied. The author, therefore, has thought it worth while to consider even the slightest.

Before describing the instrument which the writer has perfected he wishes to express his deep appreciation of the kindly assistance and advice afforded him by his friend, the late Prof. Silas W. Holman of the Massachusetts Institute of Technology, with whom the above work was originally planned and started, who encouraged and aided it in every way in his power. To him full credit is due for suggesting many of the most important features of the apparatus. Grateful acknowledgment is also made to Prof. Peter Schwamb, also of the Institute, who designed the body of the bomb and the sealing device which have been adopted.

The purpose of the author in constructing this calorimeter for his own investigations has been to produce an instrument that would be as nearly free from all the errors of existing calorimeters as it was possible to make it, and as convenient to handle as it could be made; in other words, to provide an instrument that would yield, in the hands of an expert, results of a degree

of accuracy hitherto unattainable. The calorimeter has been constructed, regardless of expense, with this sole object in view, and it is not too much to say that whatever statements are made in its favor are based upon actual results obtained in its use and all capable of absolute proof.

The instrument remedies all the defects to which attention has been called, while all operations which can be performed mechanically have been intrusted to the electric current.

The bomb is made of aluminum bronze, which transmits heat much more rapidly than steel. It is spherical in form, with the exception of a short neck through which it is charged and by means of which it can be sealed. The spherical form secures the maximum strength and capacity attainable, with the minimum weight and bulk of metal, so that the bomb requires less water to cover it, owing to its compact form, than if it had any other shape.

The bomb is closed by a lid, which is pressed directly downward by means of a nut which screws into the neck of the bomb and which bears upon a restricted area of the convex upper surface of the lid, quite near its center. The outer edge of this lid, underneath, where the area is greater, is brought into crushing contact with a light ring-washer of tin, resting upon a flat shoulder within the neck of the bomb. All twisting of the lid is thus avoided, and all binding due to the crushing of the washer is prevented, while a tight joint is invariably secured with but little effort. A light check-valve, which the interior pressure within the bomb forces upward, when the oxygen is shut off, serves to automatically confine the gas. The check-valve and closing nuts replace the long projecting stem or pin-valve of the Mahler bomb, and they are so disposed as to make it possible to completely submerge the bomb, so that no heat developed within it can escape measurement.

The calorimeter-can has a side chamber, adapted to exactly fit the casing of the electric stirrer, and a cover, which effectually prevents the escape of heat due to evaporation of liquid from the surface. The shape of the bomb and calorimeter-can are such that 1500 grams of water suffice to *completely cover* the bomb, an amount which is from 32 to 37 per cent. less than is required to only partially cover the Mahler bomb. In consequence

the range of temperature obtained by the combustion of a given weight of coal is much greater than Mahler obtains, being 4 degrees where he would obtain only from 2.52 to 2.72 degrees, and the small but unavoidable errors incidental to the reading of thermometers are thereby greatly reduced.

The outside of the bomb is nickel plated, while its interior walls are very heavily coated with pure gold, which protects them perfectly against corrosion and furnishes a sound and durable lining which transmits heat far more quickly and perfectly than enamel.

The finely pulverized coal is compressed in the form of a little disc in which a deep slot can be cut to facilitate its adjustment to the fuse-wire. The platinum crucible stand has a deep crucible within which the loop of platinum fuse-wire hangs, and upon which the single slotted lump of coal, weighing exactly 1 gram, can be slipped. From this it cannot get disconnected, for it is supported by the sides of the crucible. When all adjustments, which are readily made, are completed, the crucible stand is lowered bodily into the bomb, which is firmly held in a screw clamp, and the upper extremity of the crucible stand is adjusted to its side, in electrical contact with an insulated knob, outside of the bomb, through which an electric current may be conveyed to the fuse-wire. The arrangements are such that nothing can disturb the integrity of the adjustments when they are once made, so that miss-fires are of very rare occurrence. Moreover, the coal being in one piece, the crucible of deep form, and the crucible stand entirely in the bottom of the bomb, losses of fuel by scattering, when oxygen is admitted, or by spilling, cannot occur.

The stirring apparatus consists of an electric motor, held in position on a rod above the calorimeter, whose shaft, provided with propeller blades, is sufficiently prolonged to reach to the bottom of the calorimeter-can. The shaft revolves within a light metal casing, open above and below, in such manner that a rapid stream of water is drawn up from under the bomb and is thrown out above and around it. The stirring is rapid and perfect, and requires no attention whatever, while the speed of the propellers is sufficiently constant to have made it possible to determine

with the greatest accuracy the exact frictional effect of the stirrer and to apply the proper correction therefor to the determinations.

Finally, the water jacket, which surrounds the calorimeter, not only has the usual outside covering of felt and enamel cloth but has also been provided with a heavy cover of non-conductive material of its own, so that the space within which the operations and measurements are conducted is absolutely protected against the influence of the surroundings, and is only exposed to such influences as can definitely and accurately be known. To make doubly sure of this, the water jacket is provided with an electric stirrer of its own so that its true temperature at all times is no longer open to doubt.

The bomb having been charged, placed within the calorimeter-can, covered with a known weight of water, both covers put on and the thermometers adjusted, the two electric stirrers are set in motion and the stirring takes place automatically. The influence of the water jacket upon the calorimeter is carefully observed and, when it is found to be uniform, the charge is fired. The rise of temperature during the combustion is noted through a series of readings until the maximum is reached and the readings are continued after the maximum, to determine the after influence of the water jacket upon the calorimeter. Proper correction is made for the amount of heat introduced through the fuse-wire, the melting of which is timed with an accurate stop watch, from the dropping off of the needle of an ammeter placed in circuit.

After the combustion, the bomb is removed from the calorimeter, placed in the screw clamp, the products of combustion drawn out, and analyzed, if desired, to prove that the combustion was complete, the acids formed by the combustion washed down and carefully drawn out and the nitric and sulphuric acids formed determined by appropriate methods. A somewhat elaborate calculation is now required to correct the determination for the influence of the surroundings, acids formed, fuse and stirrer, but these corrections can all be made with the utmost precision, by calculation from the very accurate and reliable data which have been obtained. In short, a result is obtained which accurately and positively indicates the true calorific value of the fuel, without

loss of any kind, provided that the accuracy of all the instruments used has been carefully verified.

The above instrument, therefore, furnishes us the means of determining with very great accuracy the true calorific power of combustibles, it being assumed, of course, that all the precautions which have been pointed out as necessary in securing the samples have been taken.

The writer has suggested that the only sure and logical manner of purchasing coal is on a basis of its quality, as shown by analysis, and its correct fuel value by calorimeter test. This work is exclusively the work of the coal specialist, for many reasons; partly because he is best fitted to do it accurately, partly also because his position between the two parties is that of an umpire. Aside from the fact that such work as has here been described is seldom done with even an approximation to correctness, the fact remains that neither the sampling nor the calorimeter test of either the producer or the consumer can be reciprocally acceptable to the other. Two examples taken from the writer's experience may serve to make this clear.

A certain lot of 10 000 tons of " Pocahontas " coal was objected to by a consumer, on the score of clinkers. The coal dealer and the consumer sampled it together, taking out a sample weighing 65 pounds, and the request was made of the consumer to send the sample to the writer's laboratory. But, for some reason, which opens up a field for speculation, he sent only 10¾ pounds. The analysis showed:

Ash . . . . . 28.63 per cent.

Numerous analyses of Pocahontas coal, made by the writer, show that this coal generally carries on an average:

Ash . . . . . 6.16 per cent.

Agreement upon the basis of 28.63 per cent. ash being out of the question, the writer was called upon to sample the lot of coal systematically, the result showing:

Ash . . . . . 10.62 per cent.

This result while showing that this lot of coal was not up to its average quality also serves to show the unreliability of the sample sent by the consumer.

Again, the writer has analyzed the same coal as furnished for test runs on cruisers. Every lump passes through the hands of three men who reject any one containing the slightest trace of impurity; the coal is then shipped in bags. This coal showed:

Ash . . . . . 1.65 per cent.

Yet there are many published analyses of coals showing even less ash than the above extraordinary result, which the coal dealers seriously ask us to believe fairly represent the quality of the coal.

These results, from the two different points of view, simply show that the sampling or analysis of the two interested parties, however well done, can never afford satisfactory ground upon which they can meet.

The question must be settled by the coal chemist, or specialist, *acting as an umpire,* and the accuracy with which his work is performed should serve as a guaranty of fairness to both parties.

The system which has here been suggested is perfectly practical and fair, and the writer is convinced that all large purchases of coal will soon be made on that basis.

DISCUSSION.

PRES. E. C. BROOKS. We have listened with a great deal of interest to this paper, and I should like it if some of our members who are familiar with the subject would give us the benefit of some discussion.

MR. ROBERT SPURR WESTON.* Mr. President, Mr. Williams has so well covered the whole ground in such an authoritative manner and with such detail and care, that it seems superfluous for the speaker to make any remarks on the subject.

One little point, however, comes to mind, namely, the percentage of a fuel which can be utilized. It has always seemed that we should do a great deal more analytical work on the material left in the ash pile than we have done. The subject is somewhat analogous in this respect to the feeding of human beings. We know that certain foods which have higher calorific values than others do not support the body as well as others of lower values,

* Sanitary Engineer and Expert, Boston, Mass.

simply because the body utilizes a smaller percentage of the richer foods than it does of the poorer. Therefore, it seems to the speaker that we should also study the coal with respect to the boilers that it is to be used under, because certain coals will be more economical to use with certain steam plants than they will with others, independently in some measure of their thermochemical value. If we knew the fuel value of the ash from our large steam plants, we should be able to judge the value of the coal to the consumer more accurately. This, however, has to do with the combustion, not the purchase, of fuel.

I think that the position of the author, Mr. Williams, is very well taken, that all large quantities of coal should be purchased on the basis of the analysis rather than on that of the brand of coal. Mr. Williams has contributed a most interesting and useful paper, and all, especially those of us who have done laboratory work, can testify to the skill of his demonstration.

THE PRESIDENT. I would say in regard to what Mr. Weston has said about the ash pile, that I think it only requires a very casual inspection of lots of ash piles to see that the value of the fuel, a large part of it, at least, is out on the dump.

MR. EDWARD ATKINSON.* Mr. President, knowing nothing of physics or chemistry, it is perhaps unbecoming for me to say anything. My memory probably goes back further than that of any other man as to the practical application of fuel in the steam cotton mill, recalling, as I do, the first steam cotton mills that were built. At that time, of course, the practice was all empirical, and buyers bought only lump anthracite coal, thinking that the best, and from that we have come down to the refinement so accurately presented by Mr. Williams. When I was a buyer of coal on a large scale, more than twenty-five years ago, I began to take notes of all the various devices and of all the merits of one kind of coal and another, and presently I thought I would compute them together. I found that if I adopted the coals one after the other by which I was to save twenty-five cents a ton, and then applied the various devices for saving in the use of that coal, I should get to the point where my coal would cost me nothing, and I should be paid a bonus for taking it.

* President, Boston Manufacturers Mutual Insurance Company.

Later I took charge of the Boiler Mutual, and then I found that I ought to know a little more than I did, and I had to pick out men who knew more than I did, in order to conduct my part. My first point there was to find out something about the relative consumption of coal in different establishments. I adopted my customary plan of agreeing not to disclose the names of any of my clients, and I sent out circulars to a large number. They were using all the various devices, down draft and coal savers and smoke consumers, and all those things. I obtained statements ranging all the way from 1.1 pounds per horse power to 5 pounds, and I found that there was no relation one to the other, either in the devices that they used for saving fuel, or in automatic firing or hand firing, and that there was no real basis to be established from comparison or practice. All those results have been tabulated in one of my reports, and I will send a copy of that report to any member of the Association who will drop me a postal card.

Then came up the calorific value of coals. I took, not the refined methods that have been shown here to-day, but I chose my consulting engineer, Mr. R. S. Hale; tests were made with the bomb calorimeter for establishing an average range of the calorific value of the different types of coal which are offered in this market, by which in an approximate manner the relative value of the average coal offered under different names could be established. We took Pocahontas coal as the standard of one hundred and compared with that all the different types of coal now offered hereabouts. That has all been tabulated, and I have that report and will send it to any member of the Association who will drop me a postal card.

All these things are interesting and of the utmost importance. There can be no doubt whatever that coal should be bought only after careful examination, especially in large quantities, either of the most refined character, or in a general way so as to reach as close a result as can be obtained. This course will be necessary during the temporary use of coal in New England. I think the use of coal for steam boiler purposes is rapidly passing, and I expect to see gaseous fuels and the gas engine rapidly take its place for stationary purposes.

MR. EDWARD W. BEMIS.* I do not feel competent, Mr. President, to discuss the theoretical aspects of this valuable paper. All I can say directly upon it is that we believe in the principle of this testing of coal, and apply it when we purchase coal for our water works in Cleveland. We are buying three or four cars on the average every day throughout the year, usually Pittsburg slack, and every car is tested. We have an agreement with the companies from which we buy — just now it is with the Pittsburg Coal Company, last year it was with another — by which they agree to abide by our determinations. But I have often thought it would be fairer if there were some scientific laboratory in our city where the determinations could be made. At the time when coals are offered in competition for the contract for the year, we have a full test, an eight-hour run of the coal, and the bidders in competition for the contract have to agree to furnish coal equally good throughout the year, so we make their samples the standard. And then whichever company is finally awarded the contract, it is on the basis of the value of its coal as shown in the full test and also in the calorimeter test, and the company is under a contract to allow us to reduce the price proportionately to the results of our tests from time to time as compared with the sample car. We do not give them an increased price for better quality, but they agree to abide by the conditions of the specifications, which provide that there shall be a reduction for poorer quality. It is understood, however, that it shall not be made on very small percentages, but only when in our judgment there is a marked falling off. Of course the more accurate methods which have been detailed here to-day would be very valuable for us, but we do not happen to have in Cleveland a laboratory outside of the water works, except a commercial one. There is one that we used for two years, but that is simply a private laboratory that tests coal, and we finally decided that we preferred to do it in our own laboratory. If there were a laboratory connected with the Western Reserve University, we should be glad to avail ourselves of it.

MR. ATKINSON. Isn't there one at the Case School?

PROFESSOR BEMIS. There is a laboratory at the Case School

* Superintendent of Water Works, Cleveland, Ohio.

where they have tested coal, but they don't do it commercially yet, at least on any large scale. Professor Benjamin and others talked about establishing a department, I think, some months ago, but I have heard nothing about it since.

MR. ATKINSON. I will state that the case where I found an expenditure of 5 pounds of coal per horse-power on an annual consumption of 30 000 tons wasn't very far from Cleveland. I think they need something of this kind out there.

PROFESSOR BEMIS. They certainly do.

MR. WILLIAMS. May I inquire on just what basis the reduction in price is made? For instance, supposing one car load is furnished and is satisfactory and the price is settled on that; on what basis is the reduction made, and how great is the reduction in case the coal does not come up to the standard of the car load?

PROFESSOR BEMIS. Thus far we have taken the average for each month and only make a reduction in case the average falls below to a considerable degree. During the three years in which we have tested every car we have only found it necessary to dock the coal company on three or four cars. This method, of course, is not entirely fair to us, because the value of the coal would fall off to a very much larger percentage than the percentage of B. T. U.'s. However, we have made a reduction occasionally, which tends to keep the company up to time. The fact that we are testing every car is itself a very good check.

MR. WILLIAMS. I wished to know if the reduction is exactly proportional to the decreased heating power? For instance, if the quality of coal agreed upon costs $2.00 per ton and the quality delivered shows only 90 per cent. of the heat units of the standard, do you pay only 90 per cent. of $2.00 per ton?

PROFESSOR BEMIS. That is the idea in the contract. In deciding how to award the contract at the start, we go into a very exhaustive analysis, by an eight-hour run, taking one car one day and another car the next, and the agents of the companies are allowed to be present while their sample car is tested. The agents have to agree that the coal furnished is a fair sample of the coal, and each company has to specify the mine from which the coal is to be furnished, and the agent of the company agrees that the coal furnished is a fair sample of the slack coal from that mine. Before

we begin to test we have that agreed to by the competitors. Then we have a run with our engineers and with theirs present, and on the result of that is figured out which coal, taking into account the value of the coal for making steam, is the cheapest. Of course, we also run the coal for a few days after the test to see how it acts on our grates, to see whether it works up satisfactorily in every way, and usually it does.

MR. A. O. DOANE.* At the Metropolitan Water Works for the past few years we have made tests of coal, and while they may not have been absolutely accurate, the result has been very satisfactory in the quality of coal furnished. The moral effect of testing was good, as the dealers, knowing that the coal was to be tested, have been a little shy about trying to put off on us any poor coal. We test the coal that is offered by different dealers, and do not depend on any small sample which is sent in, but if possible find where a cargo of the coal has been delivered, go there and get a sample in much the same way Mr. Williams has described; that is a great point, to get a representative sample, then we make a test and also get all possible information from parties who are using the coal as to how it burns on the grates; because the calorimeter, while it determines the amount of heat units present or the calorific power of the coal, does not determine in all cases whether the coal is suitable for a particular plant or not. The particular type of boiler in use may give better results with one kind of coal than another, so that point is always looked into.

I should like to say something about specifications. Many specifications call for a coal which is equal to some well-known brand, but that of course is rather indefinite. That is, we may specify equal to George's Creek, but who knows exactly what George's Creek is? It varies considerably, and you need really to specify the mine and the shaft; I have thought for a long time that something of a more scientific nature would be much better. I should like to ask Mr. Williams if he has any general specification in mind, or whether it would be feasible to make a general specification on a scientific basis that people could use in buying coal.

* Division Engineer, Metropolitan Water Works, Boston, Mass.

MR. WILLIAMS. I believe that it is entirely feasible to lay down specifications for buying coal, based upon its quality and heating power, that would result in large economies and that would be perfectly fair to both parties. An actual example of the manner in which the scientific results can be practically applied will serve to make this clear. The United States Government is now buying all of its coal for public buildings on the basis of heat units, determined in one of my calorimeters, established some years ago at Washington. Some $220 000 worth of the best steaming coals are contracted for at one time.

The dealers originally furnished selected samples of the kind of coal which they agreed to deliver and the award was made by simply looking at the samples. It is quite impossible to obtain definite knowledge of the value of any coal by simple inspection, much less to discriminate between two coals of nearly the same quality but of slightly different appearance. It is a fact, however, that, in spite of the agreement, the quality of coal delivered seldom came up to that of the samples submitted with the bids. The next time that these were sent in, the fuel value of all the samples submitted was determined, and the contract was awarded to a coal showing 15 000 B. T. U. per pound and costing $3.00 per ton. Deliveries of 12 000 or 15 000 tons at a time then began to be made. These also were carefully sampled and analyzed, showing, we will say, only 12 000 B. T. U. per pound. The agreement calling for coal of 15 000 B. T. U., the Government simply paid for what it received: viz., twelve-fifteenths of $3.00, or $2.40 per ton. In four months the saving amounted to fully $8 000, at an estimated expense of less than $500. The above is an actual example.

There seems to be no reason whatever why, within reasonable limits, the producer should not be required to furnish exactly the grade of coal specified, and the price settled to fit the quality.

This would undoubtedly result in an enormous saving to the consumer who would get *uniform coal*, which he could handle with greater economy, and who would also *get what he pays for*. It would seem incredible that a system so just and whose advantages are so apparent has not long ago been put in practice, were

it not for the many confusing, but not generally understood difficulties, which have stood in the way. These difficulties, however, are now very nearly under control, and there seems to be no valid reason why consumers *should continue to purchase coal with their eyes shut*, and suffer the consequences, unless they really prefer to do so.

For those who do not, the following plan, among many which might be proposed, seems to the writer to be the simplest for making a practical use of the scientific results in purchasing coal in large quantities:

Specification.

1. For the producer and the consumer to agree to abide by the results of the analysis and calorimeter test of the coal, which, however, should be performed with the degree of accuracy which has been shown to be necessary, so that the result may be conclusive.
2. Then to agree upon a method of sampling the coal, following substantially the lines that have been laid down, that shall make it possible to secure a thoroughly reliable representative sample of the coal.
3. To perform this sampling in the presence of a representative of each party interested, the same as is done when valuable lots of rich ore are being sampled.
4. To send the sample for examination to a coal specialist of acknowledged reputation, acting as an umpire, who alone is capable of furnishing the reliable and conclusive results which both parties can accept.

Where facilities for fine pulverizing of the coal do not exist, samples of from 20 to 25 pounds should be sent, but where the work can be properly carried to completion, samples as small as *two ounces*, or even less, *which can readily be forwarded by mail*, with little or no delay, are sufficient.

It makes very little difference, therefore, whether the laboratory where the information can best be obtained is situated in Boston or in San Francisco, its results are readily available to all, and the advantages which result from the application of such a system, whether carried out in the manner suggested or in a slightly modified form, are so apparent that they seem to fully justify all that the writer has said upon the subject.

PROCEEDINGS.

December Meeting.

Hotel Brunswick,
Boston, Mass., December 14, 1904.

President Edwin C. Brooks presiding.

The following members and guests were present:

Members.

S. A. Agnew, Edward Atkinson, C. H. Baldwin, L. M. Bancroft, J. E. Beals, E. W. Bemis, F. D. Berry, J. M. Birmingham, E. C. Brooks, Frederick Brooks, George Cassell, G. F. Chace, J. C. Chase, R. C. P. Coggeshall, M. F. Collins, G. E. Crowell, A. W. Cuddeback, A. O. Doane, L. S. Doten, C. R. Felton, F. F. Forbes, A. D. Fuller, A. S. Glover, F. W. Gow, J. O. Hall, L. M. Hastings, V. C. Hastings, T. G. Hazard, Jr., Allen Hazen, D. A. Heffernan, H. G. Holden, W. E. Johnson, W. S. Johnson, E. W. Kent, Willard Kent, J. W. Killam, G. A. King, L. P. Kinnicutt, E. S. Larned, J. W. Locke, H. V. Macksey, D. A. Makepeace, A. E. Martin, W. E. Maybury, John Mayo, A. S. Merrill, F. E. Merrill, E. M. Peck, H. E. Perry, J. B. Putnam, W. W. Robertson, C. W. Sherman, G. H. Snell, G. A. Stacy, J. T. Stevens, C. N. Taylor, R. J. Thomas, W. H. Thomas, D. N. Tower, W. H. Vaughn, C. K. Walker, R. S. Weston, F. B. Wilkins, F. I. Winslow, G. E. Winslow. — 65.

Honorary Member.

Desmond FitzGerald. — 1.

Associates.

H. A. Desper; H. L. Bond & Co., by Harold L. Bond; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Greenwood & Daggett Co., by George F. Chace; Hersey Mfg. Co., by Albert S. Glover, J. A. Tilden and Walter A. Hersey; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by F. B. Mueller and W. L. Dickel; National Meter Co., by Chas. H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Rensselaer Mfg. Co., by F. S. Bates and C. L. Brown; Ross Valve Co., by Wm. Ross; George H. Sampson, by W. T. Page; A. P. Smith Mfg. Co., by F. N. Whitcomb; Sumner & Goodwin Co., by H. A. Gorham; Thomson Meter Co., by S. D. Higley; R. D. Wood & Co., by Wm. F. Woodburn. — 23.

GUESTS.

Hon. F. R. S. Mildon, Mayor, and George R. Hall, Marlboro, Mass.; J. J. Moore, Hingham, Mass.; H. S. Brown, Boston, Mass.; and W. H. Van Winkle, of the Water Works Equipment Co., New York City. — 5.
(Names counted twice. — 3.)

THE PRESIDENT. I have been asked to appoint a member of the Committee on Meter Rates to fill the vacancy caused by the death of Mr. George P. Wescott, and I will name Mr. Charles F. Knowlton of Quincy.

MR. CHARLES K. WALKER.* Before we proceed to the regular business of the afternoon, Mr. Chairman, I want to say a little something. Here is a recommendation which was sent to Manchester by insurance people. It came in a letter from the office of the National Board of Fire Underwriters.

NEW YORK, November 10, 1904.

MR. CHARLES E. MANNING,
President Board of Water Commissioners, Manchester, N. H.

Dear Sir, — We now hand you, at the suggestion of our inspector, a copy of the recommendations relative to improvements in the Fire Department and water supply of Manchester, and asking your co-operation in securing the same, remain,

Yours truly,
(Signed) H. K. MILLER,
General Agent.

"SUMMARY OF RECOMMENDATIONS," MANCHESTER, N. H.

Inspected, December 21, 1897. Reinspected, October 19, 1904.

FIRE DEPARTMENT.

1. There is a necessity for the organization of an additional fire company to consist of 1 permanently employed captain, 1 engineer for steamer and 2 drivers, also 10 call service firemen, 4 horses, equipped with 1 second-class steam fire engine, 1 combination and chemical hose wagon with double 35-gallon cylinders, at least 2 000 feet of first-class fire hose and service appliances. This company should be suitably located at the vicinity of Hall and Silver streets. Building improvements are rapidly increasing, also extensive shoe manufactories located nearby, and without adequate protection from the city service.

2. All electric fire-alarm wiring should be placed in an underground conduit, to insure safety from damage by storms and high winds.

* Superintendent of Water Works, Manchester, N. H.

3. The present storage battery of fire-alarm system should be strengthened or replaced by an improved new battery.

4. The requirements of the ordinance prohibiting the erection of wooden buildings and frame out-structures within the established fire limits, should be strictly enforced.

WATER SUPPLY.

1. The entire amount of 20-inch diameter, cement lined force main should be replaced by standard cast-iron pipe.

2. Owing to the uncertainty of the flow of water from the lake, to operate the water-power pumps, there is a necessity for installing one steam-power pumping engine, capacity of 8 000 000 gallons per diem, at the low-service station for reserve or emergency service.

3. The present use 2½-inch diameter hose connections on fire-service hydrants should be replaced by standard 2½-inch diameter hose and steamer, connecting discharge outlets, to insure quick service and an increased flow of water.

Now, I want to tell you, gentlemen, that it would cost $250 000 to do this work, and that is considerable money for Manchester. We have a supply from the high service with all cast-iron pipe, but the fire insurance companies want us to lay out $250 000. Well, I think they had better get out. (Laughter.) They have had all the water they wanted up to this time, they have had an abundant water supply, and they have had good luck. For an insurance company to come into the city of Manchester and tell us what to do is something I can't understand. I don't think it is right and I don't think it is fair, when they have had all the water they wanted, for them now to ask us to spend $250 000 more. I have brought this to your attention, gentlemen, so you can think it over and tell the citizens of Manchester what they ought to do. I have read this so you can see what we have to contend against. We have about so much money and so many water takers, and we want the plant to pay for itself, and we want to keep within our means. We don't propose to run into debt because some fire insurance company comes up there and tells us what we ought to do.

MR. WILLIAM ROSS. They told us in the city of Troy that we would have to spend so much money or they would put a little pink slip on our policies.

MR. EDWARD ATKINSON. I would ask the gentleman from Manchester to discriminate a bit when he speaks of insurance

companies, and tell us what kind of insurance companies they were. I should like to know where these demands came from.

MR. WALKER. I am glad Mr. Atkinson is after me, because I am after him. (Laughter.) There is no place in the New England states where they have better fire service than in Manchester, N. H., and I know there has been all the water that was needed in case of fire. Now, we don't propose to give the insurance folks all there is in the city.

MR. ATKINSON. The factories in Manchester that I am connected with have had an ample supply of water that they have provided for themselves.

MR. WALKER. I am glad of it.

The Secretary read the following communication:

METROPOLITAN WATER BOARD.

CHIEF ENGINEER'S DEPARTMENT,

SAVOY COURT, STRAND, LONDON, W. C., November 28, 1904.

Dear Sir, — I am exceedingly obliged to you for your letter dated November 17 informing me that I had been elected as an honorary member of the New England Water Works Association. Will you please convey my thanks to your Association, and state that I am exceedingly pleased to be elected an honorary member.

Yours truly,

(Signed) WILLIAM B. BRYAN.

George E. Gilchrist & Co. of Boston, manufacturers and jobbers of steam, gas, and plumbing materials, were elected to associate membership.

The first paper of the afternoon was presented by Leonard S. Doten, civil engineer, Quartermaster's Department, United States Army, Boston, Mass., it being "A Description of the Concrete-Steel Water Tower and Standpipe at Fort Revere, Hull, Mass." The paper was discussed by Edward Atkinson, F. I. Winslow, A. O. Doane, and Charles N. Taylor.

Mr. Henry J. Williams, chemical engineer, Boston, Mass., read a paper entitled, "The Advantage of a Scientific Basis for Determining the Value of Fuels," and gave a practical demonstration of a calorimeter test. On motion of Mr. Charles W. Sherman, a vote of thanks was tendered to Mr. Williams. The

subject of the paper was discussed by Messrs. Robert S. Weston, Edward Atkinson, Prof. Edward W. Bemis, and Mr. A. O. Doane.

Adjourned.

Annual Meeting.

Hotel Brunswick,
Boston, January 11, 1905.

President Brooks in the chair.

The following guests and members were present:

Members.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, J. E. Beals, J. F. Bigelow, J. W. Blackmer, George Bowers, E. C. Brooks, G. A. P. Bucknam, J. T. Cavanagh, J. C. Chase, R. C. P. Coggeshall, M. F. Collins, J. W. Crawford, L. E. Daboll, E. R. Dyer, H. P. Eddy, G. E. Evans, J. N. Ferguson, F. F. Forbes, F. L. Fuller, A. S. Glover, W. J. Goldthwait, J. W. Goodell, J. W. Griffin, J. O. Hall, J. C. Hammond, Jr., D. A. Hartwell, D. A. Heffernan, G. W. Hawkes, F. W. Hodgdon, H. G. Holden, E. J. Johnson, Willard Kent, F. C. Kimball, G. A. Kimball, G. A. King, Horace Kingman, E. S. Larned, J. W. Locke, Hugh McLean, H. V. Macksey, A. E. Martin, W. E. Maybury, A. S. Merrill, F. E. Merrill, Leonard Metcalf, H. A. Miller, J. F. J. Mulhall, F. L. Northrop, O. E. Parks, H. D. Parsons, E. L. Peene, J. W. Smith, C. W. Sherman, G. H. Snell, G. A. Stacy, J. T. Stevens, J. J. Sullivan, R. J. Thomas, J. L. Tighe, D. N. Tower, W. H. Vaughn, W. J. Wetherbee, J. C. Whitney, F. B. Wilkins, G. E. Winslow, E. Worthington, Jr., F. W. Dean. — 69.

Honorary Member.

Desmond FitzGerald. — 1.

Associates.

Henry A. Desper; Harold L. Bond & Co., by Harold L. Bond; Builders Iron Foundry, by Fred'k N. Connet; Chapman Valve Mfg. Co., by Edward F. Hughes; Coffin Valve Co., by H. L. Weston; Hart Packing Co., by Horace Hart; Hersey Mfg. Co., by Albert S. Glover, H. D. Winton and Walter A. Hersey; The Fairbanks Co., by F. A. Leavitt; Lead Lined Iron Pipe Co., by Thomas E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by W. L. Dickel; National Meter Co., by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Co., by H. H. Kinsey; Perrin, Seamans & Co., by J. C. Campbell; Rensselaer Mfg. Co., by Fred S. Bates and C. L. Brown; Ross Valve Co., by William Ross; A. P. Smith Mfg. Co., by F. N. Whitcomb; Sumner & Goodwin Co., by H. A. Gorham; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. L. Northrop and W. F. Hogan; U. S. Cast Iron Pipe & Foundry Co., by W. B. Franklin; Walworth Mfg. Co., by George E. Pickering; R. D. Wood & Co., by Wm. F. Woodburn. — 29.

GUESTS.

Mrs. Edwin C. Brooks, Cambridge, Mass.; Mrs. George Bowers, Lowell, Mass.; Mrs. H. G. Holden, Nashua, N. H.; Mrs. John C. Chase, Derry, N. H.; Mrs. Ida H. Proctor, Lowell, Mass.; Mrs. R. C. P. Coggeshall and Miss Helen R. Coggeshall, New Bedford, Mass.; Miss Mabel A. Bancroft, Reading, Mass.; Mrs. Charles W. Sherman, Belmont, Mass.; Mrs. George E. Pickering, Mrs. George A. Kimball, Somerville, Mass.; Mrs. George A. Stacy and Mrs. James F. Bigelow, Marlboro, Mass.; Mrs. F. F. Forbes, Brookline, Mass.; Miss Almira Winslow, Waltham, Mass.; Mrs. H. P. Eddy, Mrs. Henry A. Desper, Miss F. W. Desper, Worcester, Mass.; F. S. Dewey, P. M. Austin, water commissioner, C. N. Oakes, clerk water board, Westfield, Mass.; Miss Alice S. Corner, Holyoke, Mass.; Mrs. Willard Kent, Narragansett Pier, R. I.; Mr. and Mrs. Theodore Moorehead, Brookline, Mass.; Mr. and Mrs. Henry J. Williams, Mr. M. C. Hight, Mrs. A. H. Virtue, Boston, Mass.; Mrs. F. W. Dean, Lexington, Mass.; Mrs. L. E. Daboll, New London, Conn.; Mr. A. E. Blackmer, Plymouth, Mass.; Mr. Charles A. Van Keuren, chief engineer, Jersey City, N. J.; Mr. John H. Cook, Passaic, N. J. — 34.

(Names counted twice — 3.)

PRESENTATION OF GAVEL.

MR. JOHN C. CHASE. Mr. President, it lives in the traditions of an ancient fraternity, whose records are by no means inscribed in water, that the gavel is an emblem of authority and should be in the hands of all who are called upon to preside over deliberative bodies. For more than a score of years the President of this Association has been without the dignity conferred by the emblem of his high official position. The omission has not been unnoticed, and as an artificer in wood as well as a purveyor of water, it gives me pleasure to provide this gavel, and ask its acceptance by the Association.

The wood from which it is made comes from a far distant state, which was for many years my home. It is also from the one-time estate of Cornelius Harnett, a noted Revolutionary patriot, whom Josiah Quincy visited in 1770 and styled in his Memoirs as the "Sam Adams of North Carolina." Thus again, after the lapse of a century and a third, Massachusetts and North Carolina touch hands. It is a piece of water oak, a tree that in its nature and habitat naturally suggests the sturdy character and growth of our Association and the important natural element in whose procurement and distribution for public supplies and the safeguarding of its purity and plenty we are all deeply interested.

And now, Mr. President, I place this gavel in your hands. A

badge which I have seen upon your person indicates that you have been instructed in its proper use. (Applause.) During the brief time, unfortunately, in which you will have the privilege of wielding it I am certain that it will be used with credit to yourself and satisfaction to those over whom you have the honor to preside, and transmitted in due time to your successor. (Applause.)

THE PRESIDENT. Mr. Chase, in behalf of the Association I thank you sincerely for this beautiful and appropriate gift. I have pounded the table during the last year with a knife handle, as my predecessors have done before me, and I am glad that hereafter the President of this Association will have a more fitting implement. I have had in mind that, should I live to get through with my duties as President, unless some one else in the meantime should have done so, I would present the Association with a gavel, but I am pleased to have had my intention so well anticipated. I assure you I shall try to use this gavel with moderation in the few minutes remaining for me to use it and then will gladly transmit it to my successor. (Applause.)

The following applications for membership were reported as having been properly approved by the Executive Committee:

Resident. — Richard K. Hale, Brookline, Assistant to Robert Spurr Weston, Sanitary Engineer; Henry J. Williams, Boston, Chemical Engineer and Expert on Fuels; Charles T. Main, Winchester, Chairman of Water Board.

Non-Resident. — W. W. Berry, Centerville, Iowa, Superintendent of Centerville Water Works.

On motion of Mr. Coggeshall the Secretary was instructed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared elected members.

President Brooks then delivered his annual address.

PRESIDENT'S ADDRESS.

Gentlemen of the New England Water Works Association, — At the close of the year it is fitting that we should review the events of the past year and note the progress made. In doing so I congratulate the Association upon its continued prosperity and the unflagging interest taken by the membership as shown by the attendance at our meetings.

Our membership has suffered a loss by death of 16 during the past year, 14 members and 2 associates. For obituary notices, I would refer you to the JOURNAL, where a brief account of their work will be found. Our membership to-day is 604, compared with 586 of the last year, showing quite a substantial gain.

The financial affairs of the Association are in a very satisfactory condition, although not showing on the face quite as well as the last year; still, an analysis of the same will reveal the fact that extraordinary expenditures were met this year which were properly chargeable to other years.

The JOURNAL fully maintains the high character which it has held for past years, and it should be a source of pride to the Association that its standing among the scientific journals of the country is such as it is, and too much praise cannot be given to our Editor, Mr. Sherman, and his good work in connection therewith.

The usual meetings have been held the past year at this hotel and have been very fully attended.

The summer excursion to Nantasket was a perfect success, and the fall excursion to Holyoke resulted in a larger meeting than was ever held before by the Association. I think we should all join in heartfelt thanks to the water-works officials and to the people of Holyoke who so generously contributed in every way to the success of our fall meeting.

The papers presented during the year have been of more than usual interest and embrace among their number many that will be sought by the engineering world for the information contained therein.

I wish to commend the Executive Committee for their regular attendance at the meetings and for the help they have been to me during the past year.

Our Secretary has been ever zealous in forwarding the aims and ends of the Association, and to him too much praise cannot be given.

Our Advertising Agent has shown his usual energy in soliciting advertisements, and the pages of the JOURNAL show the result of his work.

It was hoped at the beginning of the year that more time might be given at the meetings to the matter of topical discussion; it

seems to be the feeling with a large portion of the membership that in that particular part of the work of the Association they are most interested and from it derive most benefit. The time at our disposal at the meetings prevents anything like a lengthy discussion, unless the papers read are extremely short. Will it not soon be necessary for us, in order to increase the usefulness of the Association, to give more time at the meetings, and have a fuller discussion of the papers, to have all the papers printed and distributed among the membership before the meetings so that the members can be prepared for a discussion of the same? The papers need thus be read only by title, and absent members can present written discussions to be read by the Secretary. In many cases where a member cannot be present a written discussion by him may add very much to the interest of the papers presented. I make this suggestion hoping that it may be considered the coming year.

The committee having charge of the question of water used by private fire supplies has certainly succeeded in attracting widespread attention to the subject, and I earnestly hope that a very full and thorough discussion may lead to some satisfactory solution of this very vexing question.

The past year a committee on uniform sizes of threads for hydrants and hose connections has been appointed. This is a matter which is of great importance in cases of great conflagrations where fire apparatus is called from neighboring cities; and although the subject has long been discussed by different bodies, with as yet little success, let us hope we may be able to accomplish something at least in that direction.

The committee on meter rates has a subject under consideration which is of great interest to water-works people all over the country. They will certainly deserve our thanks if they are able to add something to the solution of this very troublesome question.

The committee recently appointed on subjects for the meetings will be of great help to the officers of the Association and certainly add much to the interest and value of our meetings.

The present occasion offers another of the innovations in the regular proceedings of the Association, and from the attendance I think we can say that the experiment bids fair to be a success.

It is always a pleasure to have the ladies with us at these gatherings, and I think this midwinter gathering with them will certainly be looked forward to by many as one of the delightful occurrences of the year.

In retiring from the chair, I wish to thank the officers, members and associates for the cordial support they have given me during the past year, and I earnestly hope they will extend the same to my successor.

MR. STACY. If you will allow me a moment, Mr. President. Before we proceed further with the regular order of business it seems to me we ought to take some formal notice of the very useful and beautiful gift that has been made to the Association by one of our most earnest and interested members, and I therefore move that the thanks of the Association be extended to Mr. Chase for the gavel which he has so kindly presented. Adopted.

The Secretary, Mr. Willard Kent, submitted the following report:

REPORT OF THE SECRETARY.

Mr. President and Gentlemen of the New England Water Works Association, — I have the honor to submit the following report of membership, receipts and disbursements of the New England Water Works Association for the year ending December 31, 1904:

MEMBERSHIP.

The total membership of the Association January 1, 1904, was . .	586
The present membership is	604

The membership is divided as follows:

MEMBERS.

January 1, 1904.	Total active membership		528
	Withdrawals:		
	Transferred to Honorary list	4	
	Resigned	10	
	Died	14	
	Dropped	1	29
			499

	Initiations:			
	January	3		
	February	8		
	March	5		
	September	14		
	November	5	35	
	Reinstated		4	538

HONORARY MEMBERS.

January 1, 1904.	Honorary members	3	
	Elected	1	
	Transferred from members' list	4	8

ASSOCIATES.

January 1, 1904.	Total associate membership		55	
	Withdrawals:			
	Resignations	3		
	Died	2	5	
			50	
	Initiations:			
	January	2		
	February	1		
	September	4		
	December	1	8	58
January 1, 1905.	Total membership			604

SUMMARY OF RECEIPTS AND DISBURSEMENTS OF THE NEW ENGLAND WATER WORKS ASSOCIATION FOR THE YEAR 1904.

RECEIPTS.

Dues	$2 398.24
Advertisements	2 020.56
Initiations	242.00
Subscriptions	155.25
Journals sold	94.30
Sundries	82.60
June excursion	246.00
	$5 238.95

DISBURSEMENTS.

Journal (including membership list and index)*	$2 383.82
Stationery	472.48
Rent	400.00
Assistant Secretary	385.00
Editor	300.00
Advertising Agent	282.75
Reprints	221.00
Stenographer	209.50
Incidental expenses	201.10
Secretary	200.00
Stereopticon	68.43
Music	54.00
Badges	36.00
Exhibit	18.13
June excursion	296.00
Total	$5 528.21
Expenditures in excess of receipts *	$289.26

At the present time there is due the Association:

For dues	$321.75
For advertisements	483.75
For sundries	30.45
	$835.95

I know of no outstanding bills against the Association.

Respectfully submitted,

WILLARD KENT, *Secretary.*

On motion of Mr. Chase the report of the Secretary was accepted and placed on file.

The Treasurer, Mr. Lewis M. Bancroft, submitted the following report:

* Expenditures during the year include the cost of December, 1903, JOURNAL as well as the four issues of 1904, whereas receipts include returns from advertising for four issues only.

LEWIS M. BANCROFT
In account with the New England

RECEIPTS.

1904.			
January 12.	Balance on hand		$3 069.05
August 1.	Dividend, People's Savings Bank		52.40
December 3.	Dividend, Mechanics Savings Bank		36.96
February 22.	Received of Willard Kent, Sec'y	$1 490.42	
April 21.	" " " "	816.57	
May 24.	" " " "	337.55	
June 12.	" " " "	307.75	
June 27.	" " " "	246.00	
July 26.	" " " "	199.50	
August 23.	" " " "	177.30	
October 5.	" " " "	386.15	
November 8.	" " " "	509.20	
December 8.	" " " "	266.91	
1905.			
January 4.	" " " "	501.60	5 238.95
			$8 397.36

January 5, 1905. Examined and found correct.

R. C. P. COGGESHALL,
W. W. ROBERTSON,
Finance Committee N. E. W. W. Asso.

TREASURER,
Water Works Association.

EXPENDITURES.

Bills paid, as per itemized statement	$5 528.21

BALANCE ON HAND.

Deposit People's Savings Bank, Worcester	$1 451.38	
Deposit Mechanics Savings Bank, Reading	1 084.08	
Deposit First National Bank, Reading	333.69	
Total balance		2 869.15
		$8 397.36

LEWIS M. BANCROFT, *Treasurer.*

DETAILED STATEMENT OF BILLS PAID.

1904.			
February	2.	Samuel Usher, printing December JOURNAL . .	$417.80
		W. N. Hughes, printing and stamped envelopes	54.50
		Hub Engraving Co., plates	19.71
	12.	Hooper, Lewis Co., blank books	2.81
		Samuel Usher, reprints	42.25
		W. S. Greenough & Co., paper and letter file . .	2.05
		Miss J. M. Ham, salary for January	35.00
	18.	B. D. Bourne, stereopticon, January meeting .	10.00
		W. N. Hughes, cards	1.00
March	7.	Hub Engraving Co., plates	5.45
		Thomas P. Taylor, stereopticon, February meeting	10.00
		W. N. Hughes, printing	16.00
		Miss J. M. Ham, salary for February	35.00
		Boston Society of Civil Engineers, rent to February 29	100.00
		D. Gillies' Sons, printing and stamped envelopes .	123.17
	18.	W. N. Hughes, printing	3.75
		Allen, Doane & Co., rubber stamp	.90
		A. Amerena & Peters, music, February and March meetings	20.00
	23.	Charles W. Sherman, salary to April 1.	75.00
		Charles W. Sherman, postage and expenses . .	11.70
		Hub Engraving Co., plates	11.52
April	5.	Robert J. Thomas, advertising agent to April 1.	70.30
		Hub Engraving Co., plates	5.32
		Willard Kent, salary to April 1	50.00
		Willard Kent, expenses, guest tickets, etc., February and March meetings	54.20
	9.	Miss J. M. Ham, salary for March.	35.00
		Samuel Usher, March JOURNAL and reprints . .	322.75
	18.	Bacon & Burpee, report of January, February, and March meetings	73.50
	27.	Samuel Usher, printing constitution and list of members	97.50
May	3.	W. N. Hughes, printing	1.00
	11.	D. Gillies' Sons, printing.	3.35
		Hub Engraving Co., plates	1.58
	17.	W. N. Hughes, envelopes and printing	39.27
		Miss J. M. Ham, salary for April	35.00
		Miss M. J. Ham, postage, telephone, and messengers	41.20
		Amount carried forward	$1 827.58

	Amount brought forward	$1 827.58
May 25.	Wright & Potter Printing Co., printing	51.00
June 10.	Miss J. M. Ham, salary for May	35.00
	W. N. Hughes, envelopes and printing	24.00
	Samuel Usher, June JOURNAL and reprints	307.48
	Charles W. Sherman, salary to July 1	75.00
	Charles W. Sherman, postage	5.00
27.	John F. Dixon, steamer *King Philip*, June meeting	200.00
	D. O. Wade, dinners at Nantasket Point	96.00
July 5.	Miss J. M. Ham, salary for June	35.00
	A. Amerena & Peters, music at June meeting	14.00
	Willard Kent, salary to July 1	50.00
	Willard Kent, expenses June and September meetings	12.80
19.	R. J. Thomas, advertising agent to July 1	72.70
	Hooper, Lewis & Co., stationery	7.25
August 9.	Library Bureau, card index and printer's copy	40.00
	D. Gillies' Sons, printing	13.75
	Miss J. M. Ham, salary for July	35.00
15.	Samuel Usher, printing index to JOURNAL	273.00
25.	Hub Engraving Co., plates	1.12
31.	Samuel Usher, printing	4.00
September 6.	Miss J. M. Ham, salary for August	35.00
	Miss J. M. Ham, postage and messengers	36.42
30.	Charles W. Sherman, salary to October 1	75.00
	Charles W. Sherman, postage and drafting	13.00
	Whitehead & Hoag Co., badges	36.00
	Thomas P. Taylor, stereopticon, September meeting	35.43
	W. N. Hughes, printing	6.25
October 6.	Samuel Usher, reprints	24.00
	Miss J. M. Ham, salary for September	35.00
	Robert J. Thomas, advertising agent to October 1	60.00
	Willard Kent, salary to October 1	50.00
	Willard Kent, telephones, telegrams, and expenses arranging Holyoke meeting	27.40
12.	Samuel Usher, September JOURNAL	359.31
	Hub Engraving Co., plates	16.54
	D. Gillies' Sons, printing	20.75
24.	Hub Engraving Co., plates	4.77
	Boston Society of Civil Engineers, rent to August 31	200.00
	Amount carried forward	$4 214.55

	Amount brought forward	$4 214.55
	Frank E. Merrill, expenses, Committee of Exhibit	18.13
November 10.	W. N. Hughes, printing	7.00
	Miss J. M. Ham, salary for October	35.00
	Miss J. M. Ham, postage and express	58.82
	Walter Gardner, lantern slides	3.00
	Samuel Usher, printing summary of statistics	6.50
December 12.	W. N. Hughes, printing	2.00
	Thomas P. Taylor, stereopticon, November meeting	10.00
	Hub Engraving Co., plates	15.72
	Miss J. M. Ham, salary for November	35.00
	Miss J. M. Ham, letter book, postage, and telephones	12.79
	The Engineering News Publishing Co., cuts	6.00
	Boston Society of Civil Engineers, rent to November 30	100.00
17.	Charles W. Sherman, salary to December 31	75.00
	Charles W. Sherman, postage	7.60
23.	A. Amerena & Peters, music, November and December meetings	20.00
	Hub Engraving Co., plates	4.50
	Hotel Brunswick, electrical equipment	3.10
	Low's Express, teaming	6.00
24.	Bacon & Burpee, reporting September, November, and December meetings	136.00
	Robert J. Thomas, advertising agent to January 1, 1905	79.75
30.	Samuel Usher, December JOURNAL	391.65
	Willard Kent, salary to December 31	50.00
	Willard Kent, expenses	30.00
January 4.	D. Gillies' Sons, printing	35.00
	Samuel Usher, reprints	130.00
	Hub Engraving Co., plates	35.10
	Total bills paid	$5 528.21

On motion of Mr. Metcalf, the report was accepted and placed on file.

Mr. Charles W. Sherman, Editor, presented the following report:

Report of the Editor.

Boston, January 11, 1905.

To the New England Water Works Association, — The following is my report as Editor of the Journal, for the year 1904.

The December issue appears so late in the year that it is practically impossible to send out bills for advertising therein and get any returns before the annual meeting. This condition is substantially the same each year, and therefore each year's report includes the advertising returns properly belonging to the December number of the year preceding. The December issue of 1904 contained 27.92 pages of paid advertisements, which if maintained throughout the year would have an annual value of $1 935. A year ago the Journal contained 25¼ pages of paid advertisements, of an annual value of $1 750.

The accompanying tables show in detail the amount of material in the Journal, the receipts and expenditures, and a comparison with the four preceding volumes:

TABLE No. 1.

Statement of Material in Volume XVIII, Journal of the New England Water Works Association, 1904.

Number.	Date of Issue.	Number of Pages of								
		Papers.	Proceedings.	Total Text.	Index, etc.	Advertisements.	Covers and Contents.	Inset Plates.	Total.	Cuts.
1	March	72	34	106	—	30	4	6	146	11
2	June	136	4	140	—	28	4	14	186	7
3	September	84	6	90	—	30	4	12	136	1
4	December	125	30	155	9	30	4	12*	210	7
	Total	417	74	491	9	118	16	44	678	26
	Index to Transactions and Journal								116	
									794	

* Includes 8 plates not yet sent out.

TABLE No. 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XVIII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1904.

RECEIPTS.		EXPENDITURES.	
From advertisements	$2 020.56	For printing JOURNAL	$1 407.44
From sale of JOURNALS	94.30	For Index to Transactions and JOURNAL	316.75
From sale of reprints	10.55	For Preparing Illustrations	137.83
From subscriptions	155.25	For Editor's salary	300.00
	$2 280.66	For Editor's incidentals	47.00
		For Advertising Agent's commissions	282.75
		For reporting	209.50
		For reprints	221.00
Net cost of JOURNAL	648.11	For statistics forms	6.50
	$2 928.77	Gross cost of JOURNAL and Index	$2 928.77

TABLE No. 3.

COMPARISON BETWEEN VOLUMES XIV, XV, XVI, XVII, AND XVIII, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	Vol. xiv.	*4 numbers of Vol. xv.*	*Vol. xvi.*	*Vol. xvii.*	*Vol. xviii.*
Edition (copies)	1 100	1 200	1 200	1 200	900
Average membership	583	586	571	587	596
Pages of text	345	363	403	430	491
Pages of text per 1 000 members	600	618	707	733	824
Total pages, all kinds	485	536	584	619	794
Total pages per 1 000 members	832	913	1 020	1 051	1 332
GROSS COST:					
Total	$1 954.15	$2 194.26	$2 439.99	$2 706.05	$2 928.77
Per page	4.03	4.10	4.18	4.38	3.69
Per member	3.35	3.75	4.27	4.61	4.91
Per member per 1 000 pages	6.91	6.99	7.32	7.46	6.18
Per member per 1 000 pp. text	9.71	10.31	10.60	10.72	10.00
NET COST:					
Total	$347.55	$332.90	$622.89	$770.62	$648.11
Per page	.72	.62	1.07	1.25	.82
Per member	.60	.57	1.09	1.31	1.09
Per member per 1 000 pages	1.23	1.06	1.87	2.12	1.30
Per member per 1 000 pp. text	1.73	1.57	2.71	3.05	2.22

The gross cost of the JOURNAL is increasing each year, as is natural since the number of pages is increasing. The net cost, however, is less than last year, being $648.11 against $770.62 for 1903. This result is surprising in

view of the fact that the cost of the "Index to the Transactions and JOURNAL," amounting to $316.75, is included in the cost of the JOURNAL for 1904.

The total cost of the illustrations in the JOURNAL has been $300.83, or 10.3 per cent. of the gross cost of the volume.

The usual fifty reprints of papers have been furnished to their authors without charge. In addition, extra copies of their papers have been given to those Holyoke members who presented papers at the convention, in slight recognition of their energy and foresight which aided so materially in the success of the convention. The net cost to the Association has averaged $7.27 for each paper reprinted.

The present circulation of the JOURNAL is:

Members (all grades)	604
Subscribers	44
Exchanges	19
	667

The former custom of sending out three hundred sample copies of each issue has been discontinued, as it was a considerable expense to the Association with no apparent advantages.

Last year I reported that the net cost to the Association of reprinting the Pipe Specifications for sale was $22.50. This year there have been further receipts from sales amounting to $50.50, with no expenses; consequently the Association has now made a net gain on the specifications of $28.00.

I am glad to report the gradual extension of the use of the summary of statistics. The usual compilation of statistics from such summaries has been made and published in the JOURNAL.

Respectfully submitted,

CHARLES W. SHERMAN,
Editor.

On motion of Mr. Fuller the report was accepted and placed on file.

The report of the Auditing Committee was submitted by Mr. R. C. P. Coggeshall, as follows:

REPORT OF FINANCE COMMITTEE.

BOSTON, MASS., January 5, 1905.

To the New England Water Works Association, — In accordance with the provision of Article VI, Section 5, of the Constitution of this Association, it is the duty of the "finance committee" to meet on or before the day of the annual meeting and audit the accounts of the Secretary and Treasurer.

We, the undersigned members of the "finance committee" of this Association for the past year, met this day by appointment with your Secretary and Treasurer, at the headquarters of this Association at Tremont Temple, in this city, and have attended to the duty as above described.

We proceeded with the work as follows: We first examined the Secretary's cash book. We verified the additions and found the total receipts as stated therein to be correct and to the amount of $5 238.95, which amount the Secretary has transmitted to the Treasurer and holds the receipt of the latter therefor. We examined in detail the different accounts in your Secretary's ledger and have verified the Secretary's statement of unsettled accounts which the Secretary presents in his report. This we find amounts to $825.95 in detail as follows:

Dues of members	$213.00	
Dues of associates	108.75	
Due from advertisements	483.75	
Due from sundries	30.45	$835.95

The amount uncollected from advertisements, seemingly large, is due to the fact that bills for same could not be issued until the December issue of the JOURNAL had been delivered. Sufficient time has not since elapsed to make the collection of this account, but with the experience of former years before us, it is safe to predict that practically all the items of this account will be collected within sixty days.

We do not find that your Secretary is in any way responsible for the amount of unpaid dues as shown above. We are presuaded that there has been no lack of diligence upon his part in an effort to collect the same. The trouble may be wholly traced to a defect in the Constitution which allows unpaid dues to collect for more than two years.

An examination of the Treasurer's accounts shows that it agrees with that of the Secretary in the amount received, viz., $5 238.95. We have checked every item in his entries of disbursements amounting to $5 528.21 and find each item properly approved and secured by vouchers. We have checked the

Treasurer's statement of balance on hand January 2, 1905, $2 869.15 by examining his bank account.

In conclusion, your committee feel that it is due to your Treasurer, Secretary, and Assistant Secretary for us to here testify to the admirable appearance of the various books which were placed before us for examination, and we feel that the Association is to be congratulated in having its financial affairs in such competent hands.

Respectfully submitted,

R. C. P. COGGESHALL.
W. W. ROBERTSON.

On motion of Mr. Fuller the report was accepted and placed on file.

Election of Officers.

Mr. E. J. Chadbourne submitted the following report of tellers appointed to canvass ballots:

Total number of ballots 210, 4 of which were entirely blank.

For President.

George Bowers, Lowell, Mass. 206

For Vice-Presidents.

James Burnie, Biddeford, Me. 206
Frank A. Andrews, Nashua, N. H. 206
George E. Crowell, Brattleboro, Vt. 206
Frederick W. Gow, Medford, Mass. 206
Edmund W. Kent, Woonsocket, R. I. 206
Charles E. Chandler, Norwich, Conn. 206

For Secretary.

Willard Kent, Narragansett Pier, R. I. 206

For Treasurer.

Lewis M. Bancroft, Reading, Mass. 205

For Editor.

Charles W. Sherman, Boston, Mass. 205

For Advertising Agent.

ROBERT J. THOMAS, Lowell, Mass. 206

For Additional Members of Executive Committee.

FRANK E. MERRILL, Somerville, Mass. 206
GEORGE A. STACY, Marlboro, Mass. 206
JAMES L. TIGHE, Holyoke, Mass. 206

For Finance Committee.

W. W. ROBERTSON, Fall River, Mass. 206
R. C. P. COGGESHALL, New Bedford, Mass. 206
HARRY L. THOMAS, Hingham, Mass. 206

The report of the tellers was accepted, and the officers were declared duly elected. President Brooks, in calling the newly elected President to the chair, said:

I will now resign to you, Mr. Bowers, the chair, hoping that your administration may be as pleasant and in every way as satisfactory as you could wish. (Applause.)

PRESIDENT BOWERS. Gentlemen, I thank you for the honor you have conferred upon me in electing me President of the Association, and I promise you that I will faithfully carry forward the work and do all I can to assist you in keeping the standing of this Association as high as it has ever been before. (Applause.)

We have with us to-day one whom we all love to hear, and it gives me great pleasure to present to you our former President, now an honorary member of this Association, Desmond FitzGerald. (Applause.)

Mr. Desmond FitzGerald then spoke on the Manila Water Supply and Life in the Philippines, illustrated by lantern views.

Adjourned.

February Meeting.

Hotel Brunswick,
Boston, Mass., February 8, 1905.

George Bowers, President, in the chair.
The following members and guests were in attendance:

Members.

S. A. Agnew, E. Atkinson, C. H. Baldwin, L. M. Bancroft, George Bowers, D. Brackett, E. C. Brooks, F. H. Carter, G. F. Chace, J. C. Chase, S. K. Clapp, F. C. Coffin, M. F. Collins, R. J. Crowley, H. D. Eaton, H. P. Eddy, C. H. Eglee, August Fels, C. R. Felton, F. L. Fuller, J. C. Gilbert, A. S. Glover, F. W. Gow, F. E. Hall, J. O. Hall, T. G. Hazard, Jr., L. M. Hastings, V. C. Hastings, H. G. Holden, C. G. Hyde, H. R. Johnson, E. W. Kent, Willard Kent, F. C. Kimball, G. A. Kimball, G. A. King, C. F. Knowlton, H. V. Macksey, W. E. Maybury, F. E. Merrill, H. E. Perry, E. B. Phelps, W. W. Robertson, J. W. Smith, S. Smith, G. H. Snell, E. G. Smith, J. T. Stevens, W. F. Sullivan, T. V. Sullivan, R. J. Thomas, H. L. Thomas, W. H. Thomas, L. D. Thorpe, J. L. Tighe, D. N. Tower, W. H. Vaughn, C. K. Walker, W. J. Wetherbee, G. C. Whipple, F. B. Wilkins, C.-E. A. Winslow, G. E. Winslow. — 63.

Associates.

Ashton Valve Co., by C. W. Houghton; Chapman Valve Mfg. Co., by Edw. F. Hughes; Henry A. Desper; Hart Packing Co., by Horace Hart; Hersey Mfg. Co., by Albert S. Glover, J. A. Tilden, F. A. Smith and H. D. Winton; Lead Lined Iron Pipe Co., by T. E. Dwyer; Ludlow Valve Mfg. Co., by H. F. Gould; H. Mueller Mfg. Co., by W. L. Dickel; National Lead Co., by G. L. Whittemore; National Meter Co., by Chas. H. Baldwin and J. G. Lufkin; Pittsburg Meter Co., by H. F. Peck; Rensselaer Mfg. Co., by C. L. Brown; The Platt Iron Works Co., by F. H. Hayes; A. P. Smith Mfg. Co., by F. N. Whitcomb; Sumner & Goodwin Co., by H. A. Gorham; Sweet & Doyle, by H. L. DeWolfe; Thomson Meter Co., by S. D. Higley; Union Water Meter Co., by F. E. Hall and W. F. Hogan; Builders Iron Foundry, by F. N. Connet. — 24.

Guests.

W. H. Van Winkle, New York City; F. L. Weaver, water commissioner, Lowell, Mass.; J. F. Stark, president water board, Nashua, N. H.; F. A. Snow, S. C. Prescott, bacteriologist, and H. S. Brown, Boston, Mass.; W. E. Lothrop, Leominster, Mass.; Theodore Moorehead, Chinese Government Service, Shanghai, China. — 8.

(Names counted twice. — 3.)

The following were elected members:

Resident. — John Doyle, Worcester, Mass., general foreman, Worcester Water Department; Charles L. Wooding, Bristol, Conn., manager Bristol Water Company; Elbert W. Gaylord, Bristol, Conn., superintendent Bristol Water Company.

Non-Resident. — John S. Cook, Passaic, N. J., hydraulic engineer, Paterson, N. J.; J. H. Van Keuren, Jersey City, N. J., chief engineer, Jersey Water Company; Dr. T. B. Hunter, Monterey, Cal., resident engineer, Monterey Water Works.

Associate. — Roy S. Barker, Providence, R. I., contractor for well boring and test borings.

The President announced that the Executive Committee had voted to hold the next annual convention in New York City.

The first paper of the afternoon, entitled "The Maine Water District and Appraisals," was by Harvey D. Eaton of Waterville, Me. The paper was discussed by Mr. Frank L. Fuller of Boston, ex-Mayor John O. Hall of Quincy, Mr. Freeman C. Coffin of Boston, Mr. August Fels of Lowell, Mr. George A. King of Taunton, Mr. Edward Atkinson of Boston, and Prof. E. G. Smith of Beloit College, Beloit, Wis.

The next paper was on "The Kennebec Valley Typhoid Fever Epidemic of 1902–3." This was illustrated by diagrams and maps, and was prepared by Mr. George C. Whipple and Dr. E. C. Levy, the paper being read by Mr. Whipple. The discussion was participated in by Mr. Charles G. Hyde of Harrisburg, Pa., engineer on construction of filter plant, Mr. Charles-Edward A. Winslow, instructor in biology at the Massachusetts Institute of Technology, Boston, and Mr. Edward Atkinson of Boston.

Adjourned.

EXECUTIVE COMMITTEE.

TREMONT TEMPLE,
WEDNESDAY, December 14, 1904.

There was a meeting of the Executive Committee of the New England Water Works Association to-day and the following were present: President Edwin C. Brooks, V. C. Hastings, George E. Crowell, Frank E. Merrill, George A. Stacy, H. G. Holden, Willard Kent, L. M. Bancroft, Charles W. Sherman, and Robert J. Thomas.

Application of George E. Gilchrist & Co., for associate membership received and recommended.

Letter from William B. Bryan, chief engineer, Metropolitan Water Board, London, England, acknowledging election to honorary membership received and read.

Mr. Stacy, of the Subject Committee, reports that it is the unanimous opinion of that committee that the ladies should be invited to attend some one of the winter meetings of the Association. After discussion, on motion of Mr. Thomas, it was voted: That the January meeting be Ladies' Day, and that the Subject Committee be a committee with full powers to make all necessary arrangements therefor.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association, January 11, 1905, at headquarters, Tremont Temple, at 11.30 A.M.

Present: President Edwin C. Brooks, and H. G. Holden, Charles W. Sherman, L. M. Bancroft, Frank E. Merrill, J. C. Hammond, Jr., Robert J. Thomas, and Willard Kent.

Letter from Mr. F. W. Dean was read declining re-election as member and chairman of Subject Committee.

Letter from Mr. R. C. P. Coggeshall with reference to change of By-Laws in relation to payment of dues was read and referred to Executive Committee of ensuing year.

The following applications for membership were received, and it was voted to recommend the election of the applicants to membership in the Association:

Mr. Charles T. Main, mechanical engineer, 53 State Street, Boston, Mass.; Henry J. Williams, chemical engineer, 161 Tremont Street, Boston, Mass.; Richard K. Hale, sanitary engineer, Chestnut Hill Avenue, Brookline, Mass.; W. W. Berry, superintendent Centerville Water Works, Centerville, Iowa.

The President named Messrs. D. N. Tower and J. W. Crawford as tellers of election of officers for ensuing year.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of Executive Committee of the New England Water Works Association February 8, 1905, at headquarters, Tremont Temple, at 11.30 o'clock A.M.

Present: President George Bowers and members Frank E. Merrill, James L. Tighe, Robert J. Thomas, L. M. Bancroft, and Willard Kent.

On motion of Mr. Thomas, seconded by Mr. Tighe, it was voted: That the next annual convention of the New England Water Works Association be held in the month of September in the city of New York, and that the President be authorized to appoint a committee of three to make the necessary arrangements therefor.

At the suggestion of the President it was voted: That Mr. Merrill be and hereby is made a committee to make necessary arrangements for transportation.

Following the suggestion of the Finance Committee, and others, on motion of Mr. Thomas, seconded by Mr. Merrill, it was voted: That the Executive Committee recommend the following changes in the Constitution of the New England Water Works Association to be acted upon at the March meeting by the members of the Association, viz.:

That Section 1 of Article III be amended by the addition of the following clause: "All applications for membership presented to the Association for action must be accompanied by the proper initiation fee and dues for whole, or fractional part, of current year in which application is presented."

That Section 5 of Article III be amended to read: "The annual membership dues shall be payable in advance on the date of the annual meeting in January. At the expiration of ten months after the annual meeting, the Secretary shall notify each member who has not paid his dues for the current year, that unless the same are paid within thirty days, his membership in the Association shall cease; and if said dues are not paid within said period, the Secretary shall drop the name of said member from the membership roll. The Executive Committee may, however, at its discretion reinstate said person on the payment of all arrears."

That Section 4 of Article VI be amended by the addition of the following clause: "He shall deposit all funds received in such place of deposit as may be approved by the Executive Committee. All orders for withdrawal of funds and checks for disbursements shall be signed by the Treasurer and countersigned by the President."

The following-named applications for membership were received, and it was voted to recommend the same to the Association for election to membership:

As Members. — Charles L. Wooding, manager Bristol Water Company, Bristol, Conn.; Elbert W. Gaylord, superintendent Bristol Water Company, Bristol, Conn.; John Doyle, general foreman Water Department, Worcester, Mass.; T. B. Hunter, resident engineer Pacific Improvement Company's Water Works, Monterey, Monterey County, Cal.; John H. Cook, hydraulic engineer S. U. M., Paterson, N. J.; Charles A. Van Keuren, chief engineer, Jersey City, N. J.

As Associate. — Roy S. Barker, driven wells, Providence, R. I.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

OBITUARY.

HENRY A. COOK, superintendent of the Salem Water Department, died January 10, 1905. He was born in San Francisco, January 11, 1858, and was educated at Salem, where he came in 1864. He graduated at the Salem High School in 1876 and later studied at the Institute of Technology, and was in the office of Ernest W. Bowditch, civil engineer, of Boston. He opened an office in Salem in 1889 and was employed as an engineer on the Salem Water Works, laying the new main from the pumping station in North Beverly through Danvers to Salem. In the fall of 1891 he was elected superintendent of the Salem Water Works, which position he had since held. He leaves a widow, a daughter of Judge J. B. F. Osgood of Salem. Mr. Cook was elected a member of the New England Water Works Association on February 10, 1902.

J. A. MARION died at his home in Montreal, Canada, on December 2, 1904.

Mr. Marion was born at St. Simon, County of Bagot, March 31, 1871.

He was a student of the Jacques-Cartier Normal School at Montreal, from which he graduated with the Gold Medal of The Prince of Wales. He then entered the Polytechnic School and at the age of twenty he was received Engineer, with great distinction.

In 1897 he married Miss Maria Berthiaume of St. Hugues, who survives him, as also two daughters, aged six and two years.

Mr. Marion, after graduating as Engineer, spent some time in the United States. Returning to Montreal he, in 1892, opened a Patent Soliciting Office under the firm name of Marion & Marion, with a branch office at Washington, D. C.

Mr. Marion was a member of a large number of societies of engineers. He was a Bachelor of Applied Science, Laval University, member of the Canadian Society of Civil Engineers, of

the "Association des Ingénieurs Conseils en matière de propriété Industrielle" (France), of the "Chambre Syndicale des Conseils en matière de propriété industrielle" (Belgique), of the American Water Works Association, etc.

He was elected a member of the New England Water Works Association on December 13, 1893.

JOHN P. K. OTIS, president of the Union Water Meter Company, an Associate of the New England Water Works Association, died at his home in Worcester, Mass., at 1.30 o'clock Saturday morning, December 31, 1904.

John Pierce Kettell Otis was born in Worcester, March 9, 1853, and was the son of John C. and Mary E. (Kettell) Otis.

He obtained his education at the grammar and high schools in Worcester, and then began the study of engineering, which became his life's work. In 1869 he entered the City Engineer's office in Worcester, and in 1871 attended a course at the Worcester Polytechnic Institute, from which he was graduated two years later.

Mr. Otis was then appointed assistant engineer for the construction of the Springfield Water Works, and after two years there was, in 1875, appointed engineer for the construction of the Portland, Me., Water Works, a position he held until 1878. From 1878 to 1881 he was instructor of civil engineering in Worcester Polytechnic Institute. In 1880 in connection with his duties as instructor in Worcester Polytechnic Institute he assumed the position of manager of the Union Water Meter Company, of Worcester, and in 1900 was also made its president.

He was a member of the Montacute Lodge, A. F. & A. M., Worcester Royal Arch Chapter, Worcester Board of Trade, Worcester Society of Engineers, Society of Antiquity, Commonwealth Club of Worcester and Worcester Mechanics Association.

Records of the Union Water Meter Company contain the following entry, viz.:

"The Board of Directors of the Union Water Meter Company, in meeting assembled this twenty-eighth day of January, 1905, desiring to place on record expression of their appreciation of the upright manliness, strict integrity, and ever painstaking serv-

ices characteristic of their late President, John Pierce Kettell Otis, whose death occurred December 31, 1904.

"Resolved that by his death this Corporation has lost a valuable officer and each individual member a friend of whose friendship he can always think with feelings of deepest thankfulness."

MACY STANTON POPE was born at East Machias, Washington County, Me., on July 26, 1869, of sturdy New England parentage, his father, James Otis Pope, and his mother, Olive Chase, both being natives of East Machias.

His early training was obtained in the public schools of East Machias, and in Washington Academy, located in his native town, from which he graduated in 1888.

Brought up in a community chiefly interested in lumber and shipping, he spent much of his time in his father's mill and in the woods, of which his father owned large tracts. He thus acquired not only an intimate knowledge of these industries and a deep interest in them, but habits of close observation and independent thought, which marked his later life and work.

In the fall of 1888 he entered the Massachusetts Institute of Technology and graduated from the department of civil engineering in 1892.

He then entered the employ of the Associated Factory Mutual Fire Insurance Companies of Boston, taking part in a series of tests upon cast-iron water pipe and fittings being conducted at Nashua, N. H., by Mr. John R. Freeman.

In the following fall he was called to the Massachusetts Institute of Technology as assistant to Professor Dwight Porter in the department of hydraulics, but resigned his position at the end of the academic year to take up practical work again and to re-enter the employ of the Factory Mutual Company.

Here his time was divided between the testing department, in which he made tests of various fire protection and prevention devices, the inspection department in which he visited mills in different parts of the country and made plans of and reported upon them, and in the private work of Mr. John R. Freeman, then engaged in addition to his regular duties as engineer to the Factory

Mutual Company, in preparing plans for the improvement of the Pennichuck Water Works at Nashua, N. H., and of the power plant of the Piscataquis Pulp and Paper Company, and in various other kindred projects.

In February, 1898, Mr. Pope obtained leave of absence from his company to devote himself to the lumber interests of his family estate. Later, after making a somewhat extended tour through the southern and western states with his mother, he resumed his active connection with the company in June, 1900.

From this time his work lay principally in the inspection department of the company; first in routine inspection work, later in special inspections. His early training and natural traits, combined with his personal experience with the practical affairs of business, stood him in good stead and made him a most valuable man for the department. Clear headed, well balanced, and judicially minded, he was well fitted to do the work which fell to him, and merited the words of commendation of one of his associates, who wrote after Mr. Pope's death:

"It is the verdict of all that the work done in each of these various fields was well done, and that the results were received by those who used them with the fullest confidence. In every case strong common sense and a clear appreciation of relative values were predominating characteristics."

Mr. Pope was much interested in engineering matters and was a member of various engineering societies — amongst them the American Society of Civil Engineers (in which he was an associate member), The Boston Society of Civil Engineers, The New England Water Works Association, The Society of Arts, and of the Technology and Appalachian Mountain Clubs.

He was devoted to his old home and took a warm and active interest in its affairs, as was shown by his presenting to the town of East Machias, jointly with his brothers, John A. and Warren F. Pope, a new bridge across the East Machias River. This structure, a fine three-span, re-enforced, concrete masonry arch, was built to replace a dangerous old timber crib bridge, not only as a memorial to the Pope family, which had been prominently identified with the affairs of the town for a century, but as an object lesson to the community.

His Alma Mater and the Washington Academy, of which he was a trustee, also claimed Mr. Pope's interest, and were substantially remembered by bequests in his will.

Last summer Mr. Pope took the opportunity to travel abroad for some months for rest and recreation, but shortly after his return serious symptoms developed and he died of acute Bright's disease at Brookline, Mass., on December 10, 1904.

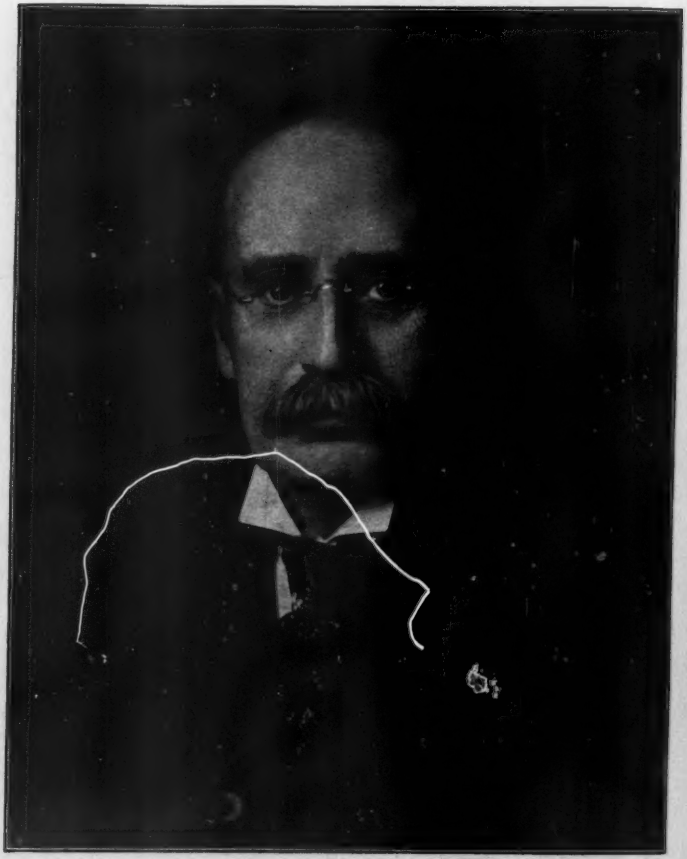
Quiet and reserved to the world, but a warm and loyal friend, simple in tastes, with high ideals, a well balanced and indomitable worker, Macy Stanton Pope will long be remembered by his friends as a good example of a fine and virile type of New Englander.

He was elected a member of this Association on March 13, 1901.

BOOK NOTICE.

"Water and Public Health." By James H. Fuertes. 12 mo. 75 pages. John Wiley & Sons, New York. Price, $1.00.

This little book discusses in an interesting manner the relations between the character of the water supplies in some seventy-five cities and the typhoid fever death-rates for the years 1890–1895 inclusive. It is profusely illustrated by diagrams. Typhoid fever is the only water-borne disease considered, and no reference is made to other means of dissemination of this disease.



GEORGE BOWERS
President, New England Water Works Association
1905